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THE UNIVERSITY OF ALBERTA

INFORMATION PROCESSING BY TEACHERS AND PUPILS DURING MATHEMATICS INSTRUCTION

by

© NORMA COLLEEN COOPER

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Information Processing by Teachers and Pupils during Mathematics Instruction submitted by Norma Colleen Cooper in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Elementary Education.

Supervisor

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Date April 16, 1979

ABSTRACT

The purpose of this study was to investigate the types of information processed by teachers and pupils during mathematics instruction, to compare teacher and pupil perceptions of the instructional process and to examine the potentialities of stimulated recall techniques for research on teaching and learning in the elementary school.

Eight math lessons were videotaped and twenty-eight interviews conducted using the videotape of the lesson as a stimulus for recall of interactive thoughts.

The subjects consisted of four teachers and twelve pupils in grades four, five and six. Two content analysis systems (SATIT and CAPIT) were used to code the transcripts of the stimulated recall interviews. This micro-analysis of the data was supplemented by a macro-analysis which sought to identify emergent phenomena.

Although the frequency of thought units recalled by teachers in each of the ten categories of SATIT varied, they all revealed a strong focus on deliberating future instructional tactics. These teachers exhibited integrative decision making and proactive teaching behaviors. They also monitored their instructional impact and relied upon contin-

gency planning and heuristic moves to achieve lesson objectives. Their interpretations, reflections and anticipations relating to pupil behavior constituted one-third of their collective interactive thoughts. The principles of compensation, accommodation, aversion and circumvention which characterized their differential treatment of pupils were identified in the macro-analysis.

Pupils differed widely in the degree to which they engaged in mathemagenic behaviors during the math lessons. The average frequency of these thought units constituted one-third of all their disclosed interactive thoughts. They were highly self-monitoring and interpreted teacher behavior and classroom events to create idiosyncratic classroom realities. Evidence of pupil self-concept, mathematical confidence, reflective ability, and introspective ability was found in the macro-analysis.

A comparison of teacher and pupil dialogue at similar nodes revealed differences in their perceptions of lesson objectives, mathematical format and teacher motives underlying instructional moves. The examination of concurrent thought processing also revealed incongruencies between what the teacher intended to teach, actually taught, and what the pupils perceived as having been taught.

No relationships between teacher education, teaching experience, teacher beliefs about mathematics and mathematics instruction and information processing styles were revealed in the study. A comparison of the results of this study with Marland's (1977) findings revealed a number of differences.

The two-phased research design did yield some support for the hypothesis that the examination of information processing styles and specific areas of inquiry can be pursued simultaneously.

The results of the study revealed the need for qualitative analyses of the stimulated recall data and longitudinal studies in determining information processing styles of teachers or pupils.

It was concluded that the introspective technique of stimulated recall provides a viable means of studying the teaching-learning process.

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

In spite of sweeping curriculum change during the 1960's in elementary school mathematics, many of the problems associated with pupil achievement and negative attitudes toward mathematics still persist. Coleman (1975) cites the deplorable attitude toward mathematics that is diffused throughout our society and fixes on "the attitudes (toward mathematics) of elementary school teachers as the strategic factor" in their propagation (p.94). Skemp (1976) claims that the widespread failure to teach 'relational' mathematics is the major cause of negative attitudes toward mathematics and the rejection of mathematics by otherwise highly-educated people, a situation which Bondi (1976) states is "surely the greatest measure of our failure (in mathematics education) and a real danger to our society." Although an inherent human resistance to the use of symbols and increasingly difficult levels of abstraction is recognized, it does not preclude efforts to overcome this resistance.

On one hand, Kline (1973) warns that unless mathematics is "revivified by the air of reality" it will not survive as an important element in liberal education (p. 151); on the other hand, Bruner (1973) states that he is "forced to the conclusion that our survival may one day depend upon achieving a requisite mathematical literacy for rendering the seeming shocks of change into something that is continuous and cumulative" (p. 477). Currently, 'math avoidance', math anxiety, and math deficiencies are problems being dealt with at the college and university levels through the development of special programs or clinics. Due to math deficiencies, both men and women but particularly the latter, are seriously affected in their career choices, for the critical vocational filter is mathematics (Sells, 1973). For these reasons greater efforts are needed in elementary mathematics education research, to ensure a sound basis and potentially strong framework for mathematical understanding and competence.

While "mathematics and reading are commonly accepted as _the_ subject curriculum in elementary schools" (Good and Grouws, 1977, p. 49), there is now empirical support for the assumption that more teacher and school variance is associated with students' performance in mathematics than in reading (Coleman, J., 1975). Consequently, future research of teacher differential effects upon student performance should include studies of teacher behavior during math instruction and its effects upon student learning.

Research in the past has focused in turn on the teacher, on the pupil, on the subject matter, and in fewer instances on the interaction of teacher, pupils, and subject matter. In the latter case, the focus has been mainly on quantitative analyses of teacher-pupil interactions where overt be-behaviors are observed and coded (Dunkin & Biddle, 1974).

Recent interest in the covert behavior of teachers and pupils, based on the premise that thought and action are inextricably interwoven, has resulted in a number of research studies which focus on the teacher's mental life and decision making (Marland,1977; Morine & Vallance, 1975; Clark & Peterson, 1976; Clark & Joyce, 1975; Marx & Peterson, 1975). In addition to observation and interviews, introspective methods using videotapes of actual lessons as a stimulus for recall of thought are being used to gain insights into the cognitive functioning of both teachers and pupils.

A major question being asked is "How do the ways teachers think - about themselves, their work, their students, their subject matter and materials, the settings in which they appear, the alternatives they consider - affect the nature and quality of their teaching and student learning?" (Shulman & Lanier, 1977, p. 44). A first step in answering the question, is to find out what teachers think before and during instruction, the types of information they process during instruction, and their conceptions of the subject matter, all of which influence their planning, goal setting, choice of instructional strategies, and teaching behavior.

A desirable counterpart would include a study of pupil covert behavior using similiar techniques. Berliner (1976) is an advocate of such studies since without them we run the risk of pursuing variables which students can't perceive or consider unimportant. In his opinion, we must consider the problem of "how students monitor and interpret a teacher's behavior in ways which may or may not coincide with how educational theorists interpret the phenomena" (p. 12). Although stimulated recall techniques have been used to some extent with pupils, Kagan (1973) advises against using them with pupils below the grade three level.

Need for the Study

Although research focusing on the analysis of teacher thought processes dates from the mid-1950's, it is only during the last decade that a renewal of interest in analyzing the mediating process of thought has emerged. Many researchers advocate the need to study the thought processes of teachers whether the focus is on teaching conceptualized as information processing, problem solving, or decision making. Nowhere is this trend more evident than in the actions taken recently by the National Institute of Education (NIE). The report of the panel on "Teaching as Clinical Information Processing" was included as part of a request for proposals issued by the NIE in 1976. According to Gage (1976) this "indicated that it (the NIE) attached special value and importance to the ideas of this panel on teaching as clinical information processing" (p. 17). The goal of this panel was to "develop an understanding of the mental life of teachers" (NIE, p. 1). It also offered a conceptual model for clinical information processing in teaching which put the teacher's cognitive processes at the center of attention. Included among the cognitive processes were expectations, perceptions, causal attributions, labeling, diagnostic judgment, hypothesis generation and hypothesis testing. This panel advocated research on covert teacher behavior to complement the research on overt teacher behavior. The panel regarded teaching as clinical acts of diagnosis, prescription, and decision making precede and determine a teacher's actions, behavior, and interactions with students. Among the methods proposed for research on teaching conceived as clinical information processing were systematic introspection or thinking aloud, the analysis of decisions, and the analysis and coding of complex descriptive protocols. The report of this panel will be reviewed in a subsequent section (Review of Related Research and Literature).

According to Smith and Geoffrey (1968, p. 96), teaching is an "intellectual, cognitive process. What goes on in the head of a teacher is a critical antecedent of what he does". Recognition of teacher cognitions as important mediating links between curricular intent and classroom practice implicitly demands research which focuses on thought processes of teachers before and during instruction. In addition, an information processing approach which employs introspective methods capitalizes on participating teacher and pupils as both research subjects and "sources of insight regarding their own functioning and behavior" (Shulman & Lanier, 1977, p. 45).

Kilpatrick (IRT, 1977) states that "research on the teacher's thoughts and behavior in teaching mathematics to elementary school pupils is .... an uncharted wilderness". He advocates the use of additional criteria such as relevance to educational theory, salience to teachers, and importance to society, for setting the focus of research. Lanier (IRT, 1977) notes the dearth in mathematics literature of descriptive analyses of teacher planning and instructing. The NACOME report (1975) emphatically recognizes this deficiency in educational research. Easley (IRT-1977) in his criticism of traditional designs of instructional systems which fail to take the conceptual systems of teachers and students into account, is supportive of educational research which focuses on teacher and pupil covert behavior. By capturing teacher and pupil interactive thought processes simultaneously, congruencies between teacher intent instructional behavior, pupil perception and conception can be explored.

There is also a need to replicate research studies concerned with teacher information processing. By using the procedures for orientation, familiarization, stimulated recall interviews and the coding system developed by Marland (1977), that part of the study employing the same focus and focal strength will yield comparable data. By varying the methodological technique (different nodes and strong focal strength), the potential of such research techniques can be explored.

Purpose of the Study

This study constitutes a further application of the use of stimulated recall techniques in educational research conducted at the University of Alberta. The groundwork for the procedures and technical requirements was laid down by Marland (1977) in his research project which was one of six collaborative studies carried out in 1975-76 at this same University (Mahen, Eggert, Fansano, Moody, Muttart). The pilot study was conducted during 1976-77 as part of phase two of a continuing research program in research on teaching under the auspices of the recently established Centre for Research in Teaching and the Department of Elementary Education at the University of Alberta.

This study was designed for three major purposes:

1. To investigate the types of information processed by elementary school teachers and pupils during mathematics instruction.
2. To compare elementary school teacher and pupil perceptions of the mathematics instructional process.
3. To explore the potentialities of stimulated recall techniques for research on teaching and learning in elementary schools.

Research Questions

The three major purposes of this study have been formulated as eight specific questions to be answered.

1. What types of information are processed during mathematics instruction by elementary school teachers?

2. What types of information are processed during mathematics instruction by elementary school pupils?
3. Are the types of information processed by elementary school teachers related to the teacher's
    - (a) beliefs about mathematics and mathematics instruction?
    - (b) education in mathematics?
    - (c) teaching experience?
4. How do the types of information processed by elementary school teachers during mathematics instruction compare with Marland's results?
5. Do differences exist between elementary school teacher and pupil perceptions of the mathematics instructional process?
6. Are there differences between elementary school teachers' recall of interactive thoughts when interviewed under varying foci and focal strength conditions?
7. Are there differences between elementary school teachers' recall of interactive thoughts when interviewed under constant foci and focal strength conditions?
8. What variables affect the use of stimulated recall techniques for research on teaching and learning in elementary schools?

Significance of the Study

An investigation of teacher intent, teacher behavior during instruction, and pupil perceptions of that behavior could reveal discrepancies and/or congruencies between two or more of these dimensions.

The findings of this study could contribute to the refinement of introspective methodology.

If inappropriate teacher behavior results from a lack of sufficient awareness of both their own behavior and pupils' behavior, mechanisms to make teachers more aware of their instructional behavior and its effect upon pupil learning need to be developed. This study could add to a data base which provides specific information for classroom situations.

If instructional behavior embodies definitive attitudes toward and conceptualizations of mathematics, perhaps emphasis on these two variables should be increased in teacher training programs.

In summary, the findings from this study may have implications for teaching, teacher training, and research methodology.

Definition of Terms

For the purposes of this study the following terms will be used as defined.

Stimulated recall: a branch of introspective methodology in which audio and/or visual records of a subject's past behavior are used to facilitate the subject's recall of the covert mental activity which was occurring simultaneously with the recorded overt behavior.

Preactive: denotes the phase of teaching which occurs prior to instruction; it may include planning or other forms of preparation for instruction.

Interactive: denotes the phase of teaching when the teacher is involved in instructional activity with children in the classroom.

Nodes: stimulus points at which the videotape is stopped by either the interviewer or the interviewee during the stimulated recall interview.

Focal strength: the degree of focus provided by the interviewer through choice of nodes and questioning techniques during the stimulated recall interview.

Content analysis: a technique used "for making inferences by systematically and objectively identifying specified characteristics of messages" (Holsti, 1968, p. 601).

Beliefs about mathematics and mathematics instruction: a conceptualization of mathematics and mathematics instruction along a formal (rigid set of memorized rules, facts, and procedures) - informal (probing, creative, involving aspects of originality and trial and error) continuum (Collier, 1972).

Heuristics: "effective procedures serving to guide, discover or reveal" (McDonald, 1971, p.77).

Heuristic teaching: "an infinite-state information processing model designed to produce effective procedures or heuristics in a learner so that he may solve problems or acquire intelligent behavior" (McDonald, 1971, p. 79).

Information processing (clinical):

aggregation and interpretation of a diversity of information sources combined with expectations, attitudes, beliefs, and purposes which form the basis for teacher responses, reflections, judgments, and decisions (Shulman & Lanier, 1977, p. 44).

CHAPTER II

REVIEW OF RELATED RESEARCH AND LITERATURE

Introduction

The purpose of this chapter is to outline the conceptual framework upon which this study is based. The first section reviews the literature that examines teaching and learning from an information processing perspective. The second section reviews the research on teaching and learning which was based on an information processing perspective. The third section examines the implications of introspective methodology for educational research. Lastly, the major premises upon which this study was based are presented.

Review of the Literature on Information Processing

It is not surprising, in view of the growing success of biofeedback and other mind techniques employed in medical research that a parallel focus in educational research has centered on the investigation of information processing by teachers before and during instruction. Whether thought processes and cognitive functioning totally determine a teacher's behavior is not the point at issue. That they are recognized as important determinants of teaching behavior warrants their investigation (NIE, 1975).

Shulman and Lanier (1977), among others, view teaching as a form of clinical information processing, a view consistent with the theory of the human processor as one whose limited capacity for processing information influences his capacity to deal rationally with the environment. While medical researchers envisage a time when knowledge of how to control useful states of consciousness will lead to an extended ability of the mind for learning and creating (Brown, 1977), perhaps educational researchers envisage a time when teacher information processing capacity can be used as a predictor of teacher effectiveness.

Shulman (1976) notes, that since he wrote a chapter for the NSSE yearbook on Mathematics Education (1970), two significant changes have taken place in both psychology (in general) and the psychology of instruction (in particular). Firstly, information processing theory has emerged from the battle ground of behaviorism and cognitive psychology. Secondly, there has been a renascence in the field of research on teaching, rather than exclusively on learning. In fact, the current movement is toward applying that same cognitive information processing approach to the phenomena of teaching. According to Shulman (1976), an information processing perspective on human learning and thinking emerges from a conception of cognition which treats the learner as a goal seeking problem-solver whose ability to deal rationally with his environment is profoundly constrained by the intrinsic limitation of his capacity for processing information. These limitations are inherent in many stages of the cognitive process such as attention, selective perception, and most significantly, short-term memory and encoding for long-term storage and retrieval. Because of his "bounded rationality", the human information-processor constructs a simplified model of real problem situations in order to cope with them. In order to understand why a person approaches a problem in a certain way we must understand three things: (1) his goals, (2) the major characteristics of the task environment, and (3) the transformation of that task environment into a cognitive problem space which reflects the limitations of his invariant information processing capacities.

Smith (1975) examines learning from an information processing perspective. His contention is that, in spite of limited information processing capacities, children know "how to make sense of the world" (p. 82) and that teachers must provide the opportunities for them to exercise their skills, to use short-term memory economically and to store only worthwhile knowledge in long-term memory. According to Smith, "an indication that much instruction is at the level of 'noise' for pupils is that verbal learning becomes content specific. That is, they can't generalize verbally acquired knowledge into divergent thinking skills as they would be able to if the new information had been assimilated meaningfully into cognitive structure." According to information theory, if the receiver of a message knows more after receiving the message than he knew before receiving it, only then is a message or signal informative. 'Noise' is defined as a signal that conveys no information. Due to human limitations in memory and visual information processing, environmental 'noise' must be ignored and attention paid only to what is relevant.

The Soviet mathematician Yu Shreider (Khurgin, 1974) in his study of semantic information has attempted to quantify the degree of change in the 'thesaurus', a Greek word meaning 'storehouse'. He pictures "the store of original information in the possession of a recipient (of a message) in the form of a lexicon (thesaurus) that not only enumerates all the words but also indicates relationships between them" (p. 301). Since thesauruses of recipients of messages are different and the ability to extract information from a message is dependent upon the informational store (thesaurus), the amount of information received by recipients of messages will vary as a function of the magnitude or development of the thesaurus. According to Khurgin (1974), "a graph of the information (received from a message) would appear as the positive arch of a sinusoidal wave, where the maximum corresponds to the recipient with a thesaurus sufficiently developed to be able to comprehend the information, but not developed to the point where the information does not involve anything new to him." The thesaurus is transformed when a new message is received and the most prepared (educated) recipient will experience the greatest transformation.

A common thread which Shulman (1976) notes emerging from recent studies, is the centrality of an understanding of the task for understanding the intellectual processes needed to perform that task. In fact, he sees a growing tradition in psychology which emphasizes the manner in which human problem solvers accommodate themselves to the demands of the task. He also criticizes his 1970 chapter for ignoring the centrality of teachers and teaching in the analysis of school learning and states that the conception of teaching which he would propose now would also grow out of an information processing perspective.

Such a perspective on teaching is evidenced in the writings of McDonald (1971) who defines heuristic teaching in terms of an infinite-state information processing model. McDonald develops a definition of heuristic teaching on the basis of the following definitions and characteristics of intelligent behavior, all of which are based on the premise that the purpose of education is to produce intelligent behavior.

(1) Teaching is an interaction between a teacher - a person who can induce intelligent behavior and a learner - a person who is acquiring intelligent behavior. (He treats teaching as a subcategory of instruction which is one subcategory of educating.)

(2) The study of teaching is the study of how the teaching behavior of the teacher produces intelligent behavior in a learner.

(3) Intelligent behavior is behavior which effectively leads to achieving a goal. Evaluating behavior as intelligent or not requires a consideration of how a person acted in light of what he hoped to achieve. Intelligent behavior can only be defined operationally within specific contexts because the criteria of intelligent behavior are culturally determined and vary within the specific domains of human activity. However, the formal relation of intelligent behavior to heuristic teaching is unchanged by the specific intelligent behavior whose acquisition is to be facilitated by heuristic teaching.

(4) Characteristics of intelligent behavior:

    (a) It is organized, and developmental in character within species and evolutionary across species. Initially, it consists of organizing sensory events into simple adaptive systems. Then more complex perceptual systems and rudimentary symbolic systems are acquired. Finally, complex, abstract symbolic systems are acquired which control a highly diverse response repertoire.

(b) These systems become increasingly more complex at each level of development. (True of a language system and of perceptual-cognitive and motor learning.)

(c) These systems are information processing systems. They are structures for encoding and transforming information, for storing it, and for generating interactions with environmental events. Earlier models of such systems either lack abstractness (associations or stimulus-response pairs) or they are limited by attempting to link neuro-physiological functioning and behavior (cell assemblies). On the other hand, conceptualizing intelligent behavior as the functioning of information processing systems generates a model whose concepts have great generality.

(d) These systems are modified by interaction with the environment through the use of feedback mechanisms. If these modifications are permanent, we say that 'learning' has occurred.

(e) These systems function in a steady-state system until a disturbance in the form of new input enters the system. Whether or not the system modifies itself to use the new input is a function of its characteristics.

He then uses these definitions and descriptions to focus on the purpose of instruction and teaching which is to generate these systems. By delineating an information processing model of the learner and using an inductive teaching example, he relates the concept of heuristics and of heuristic teaching to the mental operations generated by the learner. He calls manipulations carried out to solve a problem or discover a relation, 'heuristics'. According to McDonald, a heuristic is tentative and intuitive in character.

An infinite-state information processing system requires two features, a search capacity and a 'gimmicks' capacity both of which constitute sets of heuristics for problem solving. The first one is a set of heuristics for search and the second, a set of heuristics for testing solutions or pre-solutions to problems. An infinite-state model is different from a finite-state model in that it has an infinite memory and can recursively explore it. While an infinite-state model is an instruction-obeying system, the controlling process which guides its operations is what is called an 'effective procedure' - that is, a set of rules which tell us from moment to moment, precisely how to proceed. But unlike the finite-state model, it generates successive steps which are interdependent in the sense that the rule to be followed at step two is a function of the output of step one and may be one of an infinite number of rules that might be tried. The learner must acquire both kinds of effective procedures to solve problems, otherwise he must act as a finite system carrying out pre-programmed routines.

According to McDonald (1971), the task of teaching may be conceptualized as defining those conditions under which the learner as an information processing system may be conceptualized as a finite-state model or an infinite-state model. Once the decision is made, he may be programmed using the linear programming model as the instructional model or he may be taught effective procedures or 'heuristics' using heuristic teaching as the instructional model.

There are, however, two basic problems in developing heuristic teaching: (1) to learn what heuristics are relevant to particular domains of problems and (2) to devise the instructional strategies which are heuristic in inducing problem solving. Some attempt to codify the heuristics in mathematics has been made by Polya (1957) and Wertheimer (1959); however, a science of heuristics is needed and as yet, heuristics as method has received relatively little attention.

In listing a number of information processing tasks relevant to mathematical thinking, Davis (IRT, 1977) includes specific ad-hoc heuristics and general all-purpose heuristics as alternatives to S-algorithmic procedures. He points out that the danger of sole reliance on the latter results in an "accumulation of myriad unrelated rules (which) will untimately exceed ... (pupil) information processing capabilities" (p. 15). In Bridgham's (IRT, 1977) opinion, the series of probes illustrated in Davis' example of the use of ad-hoc heuristics is a model of the heuristic process. Simon (1971) views the use of heuristic methods which provide guidelines for highly selective searches for task simplification, as the central process in human problem solving. Landa (IRT, 1977) differentiates between algorithmic and heuristic instructional approaches. The former determine a solution process completely while the latter always contain some degree of uncertainty. Although they are different types of teaching, he does not view them as entirely separate, for algorithmic instruction need not preclude independent discovery of form by pupils. Esty (IRT, 1977) insists that "teachers must teach heuristically if they are ever to produce heuristic learning and understanding in children" (p. 135). Thus there would seem to be considerable support for the development of heuristic teaching.

The influence of an information processing approach on educational research is nowhere more apparent than in a number of studies advocated by the National Conference on Studies in Teaching (NIE , 1975). One such focus is on "Teaching as Clinical Information Processing". The members of the panel were concerned with improving knowledge about the mental life of teachers which they consider to be an important determiner of teacher behavior. Their goal was to "develop an understanding of the mental life of teachers" (p. 1), a research-based conception of the cognitive processes that characterize that mental life, their antecedents, and their consequences for teaching and student performance.

This panel viewed the teacher as a clinician, not only in the sense of someone diagnosing forms of learning dysfunction but more broadly as an individual responsible for

(a) aggregating and making sense out of an incredible diversity of information sources,

(b) bringing to bear a growing body of empirical and theoretical work constituting the research literature of education,

(c) combining all that information with the teacher's own expectations, attitudes, beliefs, purposes and,

(d) having to respond, make judgments, render decisions, reflect, and re-group to begin again.

Regardless of the method used, the panel viewed the teacher's own description of how s(he) constructs the reality of his (her) classroom as important. Teachers must not only possess relevant instructional skills but also must be able to diagnose situations in which a particular set of skills should be used. In addition, applying behavior analyses appropriately requires accurate perceptions and valid interpretations of student behavior. Certainly, new roles for teachers and new patterns of staffing should be consistent with the information processing capacities of teachers. The panel viewed improved understanding of the ways in which teachers cope with the demands of classroom life as a basis for the improvement of teaching.

Shavelson (1976) has described teaching as a "process by which teachers consciously make rational decisions with the intent of optimizing student outcomes". (p. 144). Assuming that teachers have a number of strategies from which to choose, their choice of strategy is determined by matching events within the student and the classroom with that strategy. He predicts that teachers vary in the extent to which they seek information or use information about student states of mind and student performance. In his opinion, a teacher's ability and skill in estimating student states of mind is important in teaching since they provide essential information for deciding what and how to teach.

According to Taba (1964), the teacher must be a guide of the heuristic process if autonomy of thinking is to be fostered. In her opinion, the focus "set by the teacher's questions circumscribes the mental operations which students can perform, determines which points they can explore, and which modes of thought they learn" (p. 53). Hunt (1971) sees the development of higher conceptual levels with their associated adaptive capacity and flexibility as the major educational goal. In his work on matching models he examined the interactions between teaching environments and information processing levels of students. He advocates a genotypic approach to education which emphasizes structural reorganization (conceptual) and process learning rather than a phenotypic approach which emphasizes the acquisition of specific, correct responses. Schroder (1973) makes a strong plea for process-centered education. In his opinion, freedom as a way of thought must precede freedom as a way of life. The focus in education must be on information processing, the process by which information is learned. Children must be taught how to think, to seek information and uncertainty, to cope with problems, and to process information in new and meaningful ways. According to Schroder new criteria for defining and assessing its proper role in human development must accompany innovations in education. He cites the following drawbacks of content-centered learning.

(1) The child comes to depend on others for his view

of the world. That is self-reliance is sacrificed.

(2) Pupils are motivated extrinsically rather than by an intrinsic interest in knowledge.

(3) It often leads to a dependency relationship between the training agent and the child.

(4) It fails to develop an internal sense of causation in the child.

He sees the need for emphasis on and measurement of process goals in education. We must know how pupils think as well as what they think. Their progress in information processing as well as information acquisition must be judged.

Whether the term is used or not, Shreider's change in thesaurus, Taba's development of cognitive structure, Wertheimer's productive thinking, Skemp's relational understanding, Hunt's conceptual levels, McDonald's intelligent behavior, and Rothkopf's mathemagenic activities all fall within the boundaries of information processing. And in Schroeder's view, the development of information processing skills must become a primary goal of education. To this end, more emphasis must be placed on the teaching of methods of thinking in teacher training and new models developed for research on the teaching of thinking. According to Glaser (1969), "the research task in investigating the teaching of thinking is to discover how to use overt environmental manipulations to influence covert behavior and how to make unskilled overt behavior become increasingly covert and efficient." (p. 326).

Review of Related Research

There are many types of research on mathematical learning which reflect the information processing influence. One approach employs introspective accounts of problem solving to generate a model of the cognitive steps employed by a subject. Information processing theories can also lead to particular task analyses which break down the stages of information processing necessary to perform a task. These task analyses can then be tested experimentally using procedures such as measurement of response latencies. They can be used in instructional experiments employing as independent variables, alternative conceptions of the strategies which ought to facilitate problem solving. It follows then, that if strategies can be adequately represented, instruction can be planned to enhance their mastery and to foster selection or retrieval of these strategies when needed by students.

No research model for investigating pupil information processing during instruction was found. Although relatively little research has focused on the interactive thought processes of teachers, to this writer's knowledge, there has been virtually no research done which focuses on the interactive thought processes of students. A number of researchers do however stress the information processing role of the pupil in the teaching-learning process. Anderson (1970) states that a series of mediating processes is necessary if instructional communication is to give rise to learning. These processes include noticing the stimulus, translating it into internal speech, evoking images for things and events named, and conceiving relationships among the imagined things or events. In his opinion, "the main problem for educational engineering is to discover how to alter the characteristics of the instructional task so as to force students to do all the processing required for learning" (p. 363).

In his analysis of frame formats used in programmed instruction, Rothkopf (1970) rejected the interpretation that student responses and immediate feedback have a direct effect on the acquisition of subject matter and knowledge. His analysis led him to the belief that "these operations affect the inspection activities of the student instead. The inspection activities then determine what is learned." This conclusion is analogous to McDonald's (1971) concept of heuristics for problem solving. Rothkopf coined the word 'mathemagenic' to refer to attending phenomena and defined mathemagenic behaviors as "behaviors that give birth to learning" (p. 325). His concept of mathemagenic activities implies that the learner's actions play an important role in what is learned. This concept is closely related to the distinction between *nominal* and *effective* stimuli in learning. The distinction is that the stimulus (effective) which has an effect on the student is not in simple correspondence to the stimulus (nominal) presented by the teacher. "Discrepancies result from characteristics of the receptor surfaces and from the acts by the student which transform or elaborate the nominal stimulus" (Rothkopf, 1970, p. 325). Although these acts called set, attention, orienting reflex, information processing, cognition, or rehearsal have been studied with subtle differences by researchers, in Rothkopf's opinion, they all fall within the broad boundaries of the term *mathemagenic activity*.

Berliner (1976) implicitly advocates studies of covert pupil behavior when he states that "intermediate links in the causal flow requires us to examine the student's attendancy and information processing behavior" (p. 12). In his opinion, we must consider "the student's perspective of events that impinge upon him in the classroom" (p. 12), and problems of how students monitor and interpret a teacher's behavior.

Clark and Yinger (1978) have reviewed recent research studies of teacher thinking, several of which used either talk aloud or stimulated recall techniques. The studies which focused on teacher interactive decision making and teacher planning are relevant to this study. Clark and Peterson (1976), employing Philip Jackson's (1965) preactive-interactive distinction to describe the two major phases of teacher decision making, videotaped twelve experienced teachers in a laboratory setting. Videotaped segments of the day's teaching were shown to each teacher in order to stimulate recall of what s(he) was thinking about while teaching. Structured interviews were used which focused on teacher performance, changes in pupils and teachers, changes in pupils which were important to the teachers, cue observations, and conscious teacher interactive decisions. Analysis of the interviews yielded the following results:

(1) Teachers were able to describe in general terms what they were doing in each segment but seemed less able to articulate why.

(2) Teachers considered alternative strategies only when the instructional process was going poorly. That is, the teachers were not trying to optimize instruction.

(3) Pupil participation and involvement were the primary cues used by teachers to judge how well the instructional process was going. They were not concerned about the quality of student participation. More

attention was focused on the mood of the group than on the learning being done.

(4) Organizational, affective and cognitive objectives cited by teachers never included mention of individual students; in addition, these objectives were global and general rather than specific and behavioral.

(5) Teachers rarely changed their strategies from what they had planned even if instruction was going poorly.

The researchers concluded that their information processing model of teaching was a useful way of conceptualizing what teachers think while they are teaching.

Contrasting his results with the three criteria postulated to govern professional behavior, Withall (1972) found that "most teachers have little awareness of their behavior or what impact it has on their learners and seem unable to communicate a coherent rationale guiding what they do in the classroom." He concluded that most of them never consciously monitor their professional acts. Taylor and his associates (1970) after identifying two predictors of differential teacher behavior are now considering the teacher's perceptions of classroom events as a way of understanding why teachers behave as they do and why they have differential effects upon students. Among the possible variables that may influence classroom interaction performance are a number of teacher restraints, namely his (her) perceptual structure, subject orientation, student orientation, attitudes and beliefs, all of which can be studied through intensive observation of teacher behavior, and investigation of their thought processes as reported by the teachers themselves.

Marx and Peterson (1975) investigated instructional planning by teachers in a laboratory setting. Analysis of data obtained through talk aloud techniques revealed that teachers differed considerably in their planning strategies. Morine,(1975) reporting on the procedures used in a pilot study of teacher planning and teacher perceptions noted that there are differences in the ways that teachers collect and process information (p. 7). The teachers planned and taught a mathematics lesson on the lattice after which they viewed a video-tape presenting segments of lessons taught by other teachers introducing the same content to other pupils. They were asked to indicate which specific procedures seemed appropriate or inappropriate. In one sequence of interactive events, not one teacher in the study perceived the essential attribute of a particular technique for dealing with a pupil error. Morine contended on the basis of the pilot study that 'integrative' teacher decisions are lacking in many classrooms. She proposed the following three techniques for training teachers to become more integrative in their decision making: (1) comparing alternate procedures, (2) adapting procedures to pupil differences, and (3) monitoring interactive decisions. Morine and Vallance (1975) used stimulated recall tasks to identify the types of decisions made by teachers of grade two and five. They identified three types of decisions, namely interchanges (decisions relating to instantaneous verbal interaction), planned activities (decisions relating to preactive decisions), and unplanned activities (decisions to include activities not originally part of the planned activities). They found that only four percent of the teachers' decisions resulted in unplanned activities.

A content analysis system (SATIT) was developed by Marland (1977) to analyze the data obtained from stimulated recall interviews with six elementary school teachers. A few of the conclusions drawn by Marland on the basis of his analysis of teachers' introspective reports of their interactive thoughts were as follows:

(1) Teachers were not self-monitoring to any significant extent.

(2) Teachers seldom checked the accuracy of their interpretations.

(3) Teachers did think about tactical moves to be made in the lessons but usually without considering alternatives.

(4) Cognitive linking was not a salient feature in the information processing of teachers.

He also concluded that introspective techniques, involving stimulated recall from videotaped records of teaching behavior, offer a viable means of studying the covert mental activity of teachers in the interactive phase of teaching. One result which appeared in Marland's study (p. 110) was the higher percentage of prospective tactical deliberations made by four of the teachers during mathematics instruction than during language arts instruction. Two of the six teachers did not teach a mathematics lesson for videotaping. Although the small number of teachers in the study precluded any generalizations, a comparison of his findings with the results of this study may or may not reveal consistent frequencies.

Research Methodology

Magoon (1977) traces a philosophical tradition which "emphasizes that much important behavior is actively constructed" (p. 655) and cites the claim in recent literature that "such constructions should be the most highly-valued phenomena in the social and behavioral sciences". (p. 655). He also outlines a rationale for constructivist approaches in educational research. The following assumptions upon which a constructivist perspective is based are relevant to this study.

(1) Subjects being studied must at a minimum be considered knowing beings and this knowledge they possess has important consequences for how behavior or actions are interpreted.

(2) The locus of control over much so-called intelligent behavior resides initially within the subjects themselves, although this capacity for autonomous action is often severely constrained. In other words, much complex behavior like teaching and learning might be best understood as being constructed purposely by the subjects (both teachers and pupils) themselves and cannot adequately be studied without accounting for meaning and purpose.

The use of introspective techniques in educational research necessitates a new and demanding role for both the researcher and the research subjects. Exploratory studies by necessity rely upon volunteer teachers who may have had little or no research experience. In a broader context, Foster & Nixon (1978) argue that the role of researcher should no longer be excluded from the teacher's role-set. They take issue with the traditional definition of the teacher as a passive participant in educational research and view teachers as an 'untapped resource' when perceived as collegial research partners. In citing a number of consequent implications for teacher education, they envisage orientation in phenomenological research models which investigate overt and covert components of teaching behavior as serving to "encourage teachers to reflect on the often unexamined meanings, assumptions, and intentions which underlie their own actions and behaviors as teachers ...". (p. 82). Gorbutt (1972) predicts that under such a model of teacher education, " ... teaching itself would become a self-critical research act."(p.10).

An information processing perspective is not a panacea for educational research although in Simon's opinion (1970) it does present a potentially powerful tool. Moreover present information processing theory may inhibit attempts to cut through parameters which cloak complex behaviors in teaching and learning. Human information processing is far more complex than mechanical information processing and caution must be exercised in drawing parallels between the two.

The literature since 1970 abounds with references to information processing and the promise this theory holds for educational research. Recently the term 'heuristic' as a noun or an adjective is appearing more and more frequently in the literature on learning and teaching. Certainly many of the constructs previously used in educational research fall under the umbrella of these two terms; however, the focus is sharpened and the perspective broadened through their use. Both provide a strong focus on the cognitive functioning of the learner and the teacher wherein reciprocity of influence is an inevitable consequence particularly in interactional situations. One of the research results most supportive of this influence is found in the work done by Taba (1966) on teaching strategies and cognitive functioning in elementary school children. Such a perspective also provides a framework within which many different research studies which appear fragmentary or incohesive, can be conceptualized as integral parts of theoretical development. These new constructs, while promising, are not likely to solve all the problems in education but they do provide new directions for the conceptualization of research directions, the formulation of research designs, and the synthesis of results from research on learning and teaching.

The analogy between computer information processing and human information processing itself, is somewhat misleading. For although the levels of complexity of information to be encoded, and the processes involved such as encoding, storage and retrieval are comparable, the programming is technically routinized in the former and idiosyncratic in the latter. Certainly teacher intervention which focuses on information processing skills through heuristic teaching strategies can foster a degree of uniformity, but by and large, each learner determines his (her) own processing procedures. Moreover, in human information processing, the encoding procedures involve emotional layers of varying levels or intensities which sieve and separate as well as compartmentalize the imformation in ways which determine its accessibility for retrieval from memory storage. When negative emotions sheath information cells in storage, an inhibitory effect on decoding results. So that while heuristic teaching strategies might well foster the development of encoding and decoding skills, this emotional sheathing may short circuit contact points between transitional processing. Thus, in spite of heuristic teaching strategies and valid teacher judgment of thesaurus levels, resultant pupil progress may not meet theoretical expectations since the inhibitory effects of emotional sheathing are only partially controllable through teacher intervention.

Premises

Abstracted from the literature and research on information processing, the use of heuristics in instruction, and research methodology are the following premises which this investigator deems crucial to the basis upon which this study is structured.

A. 1. That cognitive development is one of the primary goals of education.
   2. That sustained learning skills are ultimately teacher independent.
   3. That learning is influenced by mathemagenic behaviors.

B. 1. That heuristic teaching is essential to fostering cognitive development and sustained learning skills.
   2. That instructional goals must include strong conscious objectives to nuture the use of heuristics in pupil information processing.
   3. That teacher instructional behavior and information processing must reflect these instructional goals.
   4. That instructional behavior is determined to some extent by the information processed during instruction.

5. That instructional strategies influence the mathamagenic behaviors of pupils.

C. 1. That descriptive small-scale studies of teacher and pupil information processing are a prerequisite to large-scale or experimental studies on information processing during instruction.
2. That the stimulated recall interview, as an introspective research technique reveals facets of the mental life of teachers and pupils during instruction.
3. That stimulated recall data reveals bases for teacher and pupil behaviors during instruction.

Summary

Recent literature on teaching and learning reveals a growing interest in information processing as a viable perspective for examining the two processes. Since information processing capacities influence the quality of both teaching and learning, there is a need to develop an understanding of the pre-emptive covert intellectual processes which precede and accompany the overt behaviors of both teachers and learners. When learners are viewed as information processors, the teacher's task is to generate increasingly more complex levels of information processing systems in learners through heuristic teaching. This is an approach which fosters autonomy of thought. And crucial to mathematical thinking is the use of heuristics which can prevent information over-load, an ultimate consequence of excessive reliance upon algorithmic procedures. These views portend an emphasis on and measurement of process-centered education, the identification of general and specific heuristics and the development of heuristic instructional approaches. That is, learning strategies must be taught by teachers skilled in 'thinking' modes.

While most of the recent research based on an information processing perspective was conducted with teachers as subjects, several researchers emphasize the information processing role of the pupil in the teaching-learning process. The learner is conceived of as an active agent whose learning is determined predominantly by his mathemagenic behaviors. These researchers advocate an investigation of covert pupil behavior and of instructional strategies which increase and promote higher levels of pupil information processing. Several research studies on teacher thinking which focused on interactive decision-making and planning have found introspective techniques to be a viable means of studying the mental life of teachers. A data base is emerging from these studies which has significant implications for the improvement of instruction and for teacher training.

Concomitant with the use of introspective techniques in educational research are the assumptions which underlie a 'constructivist' perspective. Research subjects whose complex behavior is examined are knowing beings with a capacity for autonomous action and their construction of behavior must be studied in light of purposes and meaning. In addition these techniques demand a new role for both the research subjects and the researcher, one in which as collaborative partners both require expertise in phenomenological research methods.

An information processing perspective in educational research and a growing interest in the use of heuristic teaching and learning may constitute the harbingers of an exciting new focus to research, one which may have the potential for synthesizing an amorphous mass of research results into a theoretical base.

This study which was based on premises relative to information processing theory, heuristic teaching and introspective methodology was exploratory in nature. The insights revealed may well be more significant than the answers to the questions posed.

CHAPTER III

RESEARCH DESIGN, PROCEDURES AND METHODS OF ANALYSIS

The purpose of this chapter is to describe the research design, the sample used, data sources, procedures followed, and the methods of analyzing the data collected.

Research Design

Outline

This project was a small-scale descriptive study conducted in a natural setting. The mathematics lessons videotaped were planned and taught by the teachers without intervention by the researcher or the research design. After each lesson was videotaped, a stimulated recall interview (SRI) was conducted on the same day with the teacher and with at least two pupils in the class. The SRI's were audiotaped, transcribed, and the data analyzed to determine the types of information processed by teachers and pupils during mathematics instruction. This data also provided a basis for seeking an understanding and explanation of the phenomena revealed in the SRI's. A minimum of eight teacher SRI transcripts and sixteen pupil SRI transcripts was deemed sufficient to yield a data base for the further refinement of analytical and procedural techniques which could be used in the investigation of concurrent teacher and pupil information processing.

Sample

The subjects in this study volunteered to participate. Principals were approached and teachers designated as likely candidates were interviewed by the researcher. Two criteria used in the selection of volunteer teachers were:

(1) That the teachers were currently teaching mathematics to one or more classes.

(2) That the teachers were able to make a commitment to at least four hours involvement in the study after school hours.

Of the six teachers who were interviewed, the last four volunteered to participate in the study. Students were chosen on the basis of four criteria.

(1) The pupil must be in grade four, five, or six.

(2) The pupil must be above average or high in mathematics achievement.

(3) The pupil must be able and willing to communicate interactive thought processes.

(4) The pupil must return a signed letter from the home permitting him (her) to engage in the re-

search project. (See Appendix J.)

Of the four teachers who volunteered to participate in the study, two were male and two were female. This number of teachers was chosen for the following reasons:

(1) This number of teachers would provide some contrast among presage variables, beliefs systems about mathematics and mathematics instruction, information processing styles, and instructional behavior.

(2) This number of teachers, at least one in each of the grade levels four, five, and six would provide some variability in the mathematics content being taught and in the age-levels of pupils being interviewed.

(3) A minimum of three SRI transcripts per lesson videotaped or 24 in total would provide sufficient data upon which to evaluate the stimulated recall methodology.

Only pupils above average or high in mathematics achievement were used in the study as teachers were reluctant to release pupils low in math achievement from class time.

The size of the classes varied. There were 22 pupils in the grade 3-4 class, 27 in the grade 4-5 class, 28 in the grade 5 class and 29 in the grade 6 class. The classrooms in which the research was conducted were self-contained although two classrooms in one school were almost double the size of the classrooms in the other school in floor area. The grade 4-5 and grade 6 classrooms were spacious compared to the relatively crowded conditions of the grade 3-4 and grade 5 classrooms.

The total sample consisted of the following:

1. Two elementary schools in the same school system located several blocks apart in two residential areas of a large urban center.
2. Two teachers from each school.
   One teacher at the grade 4-5 level.
   One teacher at the grade 6 level.
   One teacher at the grade 3-4 level.
   One teacher at the grade 5 level.
3. Twelve pupils.
   Two from grade 6.
   Two from grade 5.
   Two from grade 5 (grade 4-5 class).
   Two from grade 4 (grade 4-5 class).
   Four from grade 4 (grade 3-4 class).

Upon the recommendation of the teacher, four pupils in each of the four classrooms were asked to participate in the study. Four were initially approached in case of absenteeism and/or lack of parental consent, although only two students from each classroom were to be interviewed. Both contingencies occurred in the pilot study and in the research study. All teacher SRI's were conducted after school hours on the same day as the lesson was videotaped while pupil SRI's were conducted on that same day during school hours. When possible, the same two pupils in each class were interviewed twice, once each at the conclusion of each of the two videotaped lessons. In the split grade 4-5 class, six pupil stimulated recall interviews were scheduled but due to the absence of one student only five were conducted. In the split grade 3-4 class, only the grade four pupils were interviewed but due to a misunderstanding four pupils were interviewed after the first lesson was taped while three were interviewed after the second.

There was no special grouping in the classes other than by grade in the two split grade classes. All members of the same grade were heterogeneously grouped, although the split grade 3-4 class was above average in mathematics achievement according to the teacher. There were four grade three pupils in this split class but only instruction to grade four was videotaped. During the taping of the two mathematics lessons in this class, not a single interruption by the grade three pupils occurred. The teacher had planned seatwork for them and no verbal exchange occurred between the teacher and these four students during the taping of either lesson.

Eight mathematics lessons were videotaped and 28 SRI's (8 with teachers and 20 with pupils) conducted. The twenty-eight SRI's were audio taped and transcribed for subsequent coding.

Pilot Study

Training in introspective research methodology as well as training in the technical operation of equipment used preceded a pilot study which was conducted over three months in four different schools. Eleven lessons instructed by eight different teachers of grade three, four, five, and six were videotaped. Seven of these lessons were in mathematics and four in language arts. Stimulated recall interviews were conducted with both teachers and pupils. All SRI's were recorded on audio tapes, transcribed, analyzed and coded.

During the pilot study the number and depth of probing questions were varied in both teacher and pupil stimulated recall interviews to assess their impact on recall and on the rapport established between the interviewer and interviewee. Teachers were given a choice of either operating the audio-video equipment during the SRI or signalling the interviewer when they recalled thoughts or feelings. Seven out of eight teachers chose not to operate the equipment. The researcher operated the equipment during all pupil SRI's. On the basis of the pilot study, guidelines were formulated for use in the collection of the research data. Some of the factors considered during the pilot study were as follows:

1. Videotape viewing conditions.
2. Choice of audio-video equipment.
3. Length of lesson taped.
4. Length of videotape viewed.
5. Length of the stimulated recall interview.
6. Degree of focal strength set by the interviewer.
7. Choice of nodes by the interviewer.
8. Structured or non-structured interviews.
9. Selection of pupils to be interviewed on the basis of age, verbal skills, personality, and mathematics achievement.

Stimulated recall interviews were conducted with the teacher after each of the lessons was videotaped. These interviews were conducted within 24 hours after the videotaping was completed. In one case, due to teacher illness, a SRI was not conducted. The teacher SRI's were conducted after school on the same day that the lesson was videotaped or prior to school hours on the morning after the lesson was videotaped. Ten SRI's were conducted with eight teachers, two of whom were interviewed twice. Nine pupil SRI's were conducted during school hours.

Difficulties were encountered in obtaining private interviewing accommodation, in the choice and operation of the audio-video equipment, in the choice of students to be interviewed and in obtaining recall data that focused on the investigator's area of interest. Two grade three students who were interviewed experienced difficulties in recalling their interactive thoughts and tended to focus on those facets of the lesson unrelated to lesson content. Several pupil SRI's required frequent interviewer initiation of dialogue to keep the pupil's mind on the purpose of the interview as s(he) became more involved in viewing the videotape than in recalling interactive thoughts. In two instances, under strong probing, one teacher and one pupil became defensive. Such a reaction might preclude a second interview with each perchance either perceived the interviewer as being evaluative. After testing a number of microphones, sound mixers, camera lenses and VTR's, those deemed most effective were chosen for use in the research study. On the basis of the ten teacher SRI's and the nine pupil SRI's, the following guidelines were formulated.

(1) The audio-video equipment would be operated by the interviewer rather than the interviewee to facilitate maximum concentration on recall.

(2) All SRI's would be conducted on the same day as the lesson was videotaped to facilitate maximum recall.

(3) Private interviewing accommodations would be necessary for conducting the SRI's.

(4) Interviewee previewing of the videotaped lesson would have to preceed initiation of the SRI.

(5) The length of the lesson videotaped would be 30 to 40 minutes in order to ensure complete viewing by the interviewee and an SRI of approximately one hour.

(6) Only students in grade 4, 5, and 6 would be interviewed.

Since this investigator was interested in interviewee foci of information processing, teacher and pupil perceptions of the instructional process, teacher intent, and pupil understanding of lesson content, it became apparent that the research design would require two stages. The first stage would be designed to investigate teacher and pupil information processing foci, while the second stage would be designed for comparative purposes. In addition, a semi-structured questioning technique was deemed a necessary part of the second stage in teacher SRI's to elicit teacher responses to questions concerning certain aspects of instruction that were seldom mentioned in their recall. To this end, a research design was formulated to:

(1) elicit spontaneous and full disclosure by the interviewee of interactive information processing foci. This would be facilitated by minimizing interviewer choice of nodes and maintaining a moderate focal strength in probing questions. (Stage 1).

(2) compare teacher and pupil perceptions of the instructional process. This would be facilitated by interviewer 'initiation of dialogue' at similar nodes chosen by the interviewer during the SRI's and an increase in the focal strength of probing questions. (Stage 2).

(3) to elicit teacher responses to questions concerning introductory approaches, the use of mathematical terminology, choice and sequencing of examples, mathematical format, questioning strategies, and alternate instructional methods such as inductive, deductive, or heuristic. This would be facilitated by incorporating a semi-structured question schedule in the second teacher SRI. (Stage 2).

This research design would require two SRI's per teacher and two per pupil. In the first SRI, the focus of recall would be set by the interviewee whereas in the second SRI the focus would be set predominantly by the interviewer.

Although the training period and pilot study enabled the researcher to experiment with and refine the techniques in interviewing and in operating the audio-video equipment, a fundamental purpose which the pilot study served was the formulation of a semi-structured interview schedule which could tap guiding principles to instructor behavior which might not be revealed in the stimulated recall data. This disclosure could then be related to instructional behavior and interactive information processing data. The pilot study was also considered basic to the formulation of procedures for interviewing pupils, to establishing suitable rapport with both teachers and pupils, and to the construction of a research design which would elicit information from both teachers and pupils that would facilitate the answering of the research questions posed.

Design Features

Two mathematics lessons were videotaped for each teacher. The first lesson in each case was an introductory lesson on a new topic. The second lesson taught by each teacher was on a topic in the same unit as the first lesson. The second lesson was taught and videotaped three to seven days after the first one was videotaped. The purpose of this schedule was to enable the researcher to examine the recall data for evidence of relevant phenomena such as integrative decision-making, cognitive linking and integrated mathematical content. Stimulated recall interviews were conducted after each videotaped lesson with the teacher after school and with two or more pupils during school hours. All stimulated recall interviews were conducted on the same day as the lesson was videotaped. Each interview was conducted separately with either a teacher or a pupil.

The first interview with each teacher followed the explicit guidelines of Marland (1977). That is, a preactive interview was conducted with each teacher prior to the lesson, the lesson was then videotaped, and then a stimulated recall interview was conducted. The stimulated recall interview (SRI) was conducted using similiar nodes ('nodes 1') as a focus and the same questioning protocol of moderate focal strength. The following stimulus points constituted a 'nodes 1' focus:

The interviewer may stop the video tape when:

(1) the teacher asks a non-volunteer to respond to a question.

(2) a pupil's answer to a teacher's question is incorrect.

(3) a student initiated question (relevant) occurs.

(4) a student initiated comment (relevant) occurs.

(5) a pupil's answer is partly correct.

(6) there is a behavior-related teacher-afforded warning.

(7) the lesson is not proceeding smoothly.

(8) the students are disruptive and noisy.

(9) non-verbal cues occur.

The questions asked by the interviewer during the SRI with the teacher focused on the teacher's covert thoughts, feelings, sources of these thoughts and feelings, conscious choices and decisions about what to say, not to say, do, not to do next, sets of alternatives from which the choice was made and the reasons for making the actual choice. Questioning strategies which constituted a moderate focal strength included the following:

(1) Four types of questions were asked by the interviewer - initial "open-ended" questions to start the verbal exchange, probing questions if the interviewee did not give reasons for his (her) response, clarifying questions if the interviewer was not certain of the relationship between the response and the stimulus point, and confirming questions to differentiate between interactive and non-interactive thoughts.

(2) Emphasis was placed on the teacher initiating the

verbal exchange. When the interviewer initiated the verbal exchange, probing questions were limited, to avoid placing undue emphasis on any stimulus point.

(3) Guidelines (Fuller & Manning, 1973) were followed to ensure "psychology safety" for the interviewee. The interviewer was non-evaluative at all times. Since a confrontation between the interviewee and his (her) behavior was not the purpose of the SRI, a constant focus on recalling interactive thoughts and feelings was maintained. Errors by either the teacher or a pupil were not cited by the interviewer.

In the second SRI with each teacher, the nodes ('nodes 2') which constitute the focus, were chosen predominatly by the interviewer and a strong focal strength in the questioning strategies employed. The following guidelines were used in choosing the stimulus points for 'nodes 2'. (Balka, 1974).

(1) Does the teacher ask divergent open-ended questions?

(2) Are the divergent, open-ended questions appropriately phrased, sequenced, and paced?

(3) Are students given an opportunity to consider and evaluate mathematical ideas and to think through their consequences in a mathematical situation?

(4) Are students given an opportunity to discover patterns in mathematical situations?

(5) Are students given the opportunity to develop their ability to sense what is missing from a given mathematical situation and to ask questions that will enable them to fill in the missing mathematical information?

(6) Are students given the opportunity to develop their ability to split general mathematical problems into specific subproblems?

Questioning strategies which constituted a strong focal strength included the following:

(1) The interviewer will feel free to stop the tape and initiate the verbal exchange at any relevant stimulus point.

(2) The number of probing questions will be greater than in the first SRI but spaced and moderated to avoid defensive reactions on the part of the teacher.

(3) The following probing questions were asked of each teacher in the second SRI and spaced throughout the viewing of the videotaped lesson. Questions 5,6, and 7 were asked at the conclusion of the viewing.

1. Introduction:

   Question (a) Why did you introduce this concept in that manner?

   (b) Why did you use those terms of reference?

   (c) Do you think that the students had the mathematical knowledge and skills to understand the new concept?

2. Examples and sequencing of examples:

   Question (a) Why did you use that (those) example(s)?

   (b) Why did you sequence the examples in that manner?

3. Format: (verbal, non-verbal, notation, imagery)

   Question (a) Why did you use that format?

   (b) Do you think that the students understood that format?

4. Questioning strategies:

   Question (a) Why did you ask that question?

   (b) Why did you ask John that question?

   (c) Was the student using the right method to solve the problem? (wrong answer from student).

   (d) Why did you ask someone else that same question?

   (e) Are the students able to verbalize their mathematical thinking?

5. Problem-solving approaches:

Question (a) Do you ever use a different approach and if so, why did you use this one?

(b) Why do you use more than one approach?

6. Inductive versus deductive methods:

Question (a) Would you classify your method as inductive or deductive?

(b) Do you tend to use one method more than the other, and if so, why?

7. Teaching strategies for problem-solving:

Question (a) Do you teach strategies for problem-solving and if so, why?

(b) Do you think that students need to be taught strategies for problem-solving and if so, why?

Some of the strategies which a teacher may use to teach heuristics include the following:

(1) S(he) can model the behavior which s(he) intends the students to emulate.

(2) S(he) can explicitly define the effective procedures or heuristics and encourage students to supplement these.

(3) S(he) can elicit through an inductive approach, those heuristics which the students are capable of deriving and then supplement these.

These three approaches are based on the suppositions that:

(1) The teacher is cognizant of specific and general heuristics in solving mathematical problems and that

(2) The teacher is capable of implementing heuristic teaching methods.

In turn, these suppositions imply that(1) the teacher has a relational understanding of mathematics and (2) s(he) views mathematics and mathematics instruction as creative, informal, and investigative in nature. If these suppositions are false, the teacher may be operating under cognitive constraints which limit his (her) ability and/or desire to teach heuristics in mathematics.

In the absence of any identifiable approach (of the three listed above) or combination of these approaches, one way in which the degree of teacher-intended heuristic teaching can be ascertained is through teacher stimulated recall interviews. The six major questions which served as guidelines for choosing stimulus points in 'nodes 2' together with the seventeen probing questions in seven catagories constituted a strong focus on heuristic teaching stragegies.

Pupil stimulated recall interviews following the first videotaped lesson focused on nodes chosen predominantly by the pupil. The questioning strategies were of moderate focal strength and primarily confirmed interactive information processing or elicited reasons why the pupil thought or felt a certain way during the instruction. Stimulated recall interviews with the pupils following the second videotaped lesson focused on nodes chosen predominantly by the researcher. The focus centered on the pupil's perceptions of the instructional process at nodes similiar to those used in the teacher's second SRI.

The teacher SRI's from both lessons videotaped were analyzed and coded using the SATIT system (Appendix E) developed by Marland (1977). This researcher was trained in the SATIT coding system for micro-analysis and reached an intercoder reliability coefficient (Scott, 1955) of .72. A content analysis system (CAPIT) was developed for the purpose of coding pupil SRI's.

7

Research Methodology

In addition to the technical skills required to operate the audio-video equipment, skills in various techniques of interviewing for specific purposes were demanded by the nature of the study. While the guidelines for stimulated recall interviewing of teachers and pupils were similar, the pupil SRI's required a somewhat different approach as did the semi-structured second SRI with each of the teachers. All interviewees were informed of the different nature of the second SRI and at the same time encouraged to concentrate on maximum disclosure of their interactive thoughts and feelings. Caution was exercised to ensure "psychological safety" of the interviewees and additional measures taken to put the pupil interviewees at ease.

This researcher worked independently throughout the study. All preactive teacher interviews, videotaping, and stimulated recall interviews were carried out by this researcher. Because the videotape of the lesson could not be previewed before the commencement of the first pupil SRI, notes of critical events and accompanying VTR counter readings were made by the researcher in conjunction with operating the A-V equipment during the videotaping of each lesson. These notes were crucial in choosing the nodes for interview questions addressed to both teachers and pupils in the SRI's and particularly so for the second SRI's.

Technical Equipment

The following audio-video equipment was used in this study.

A Sony video camera.

A zoom lens and a wide-angled lens.

A Sony AV 3600 Solid State videorecorder.

A Sony Solid State 110 monitor.

A Sony F-540 microphone.

A Sony Cassette tape recorder.

The videorecorder chosen was reel-to-reel with half-inch tape since the cassette model prolonged the viewing of the videotaped lesson due to slippage. The tape recorder was used to tape both the SRI's and the preactive lesson interviews. The wide-angled lens was used in two of the four classrooms due to the large size of the rooms. The pilot study had revealed a need for capturing the maximum coverage of the classroom and the pupils in it in order to facilitate recall in particular and to avoid the irrelevant interjections by both teachers and pupils during the SRI's that related to incomplete pictures of classroom events.

Familiarization Phase

During the week preceding the first videotaping of a lesson, the researcher was introduced to each class and the purpose of her presence explained to the students. Each class was observed in mathematics lessons as well as in other subject areas, filmed once or twice and one video film was shown to the teacher and students. During this week, the researcher memorized the pupils' names, became familiar with classroom procedures and class schedules, and in general became a familiar presence in everyday routines. These familiarization procedures were considered necessary for the following reasons:

(1) To maintain normal classroom behaviors.

(2) To allay any feelings of mistrust.

(3) To eliminate any focus on the camera or the researcher by either the teacher or the students.

Stimulated Recall Interviews (SRI's)

A. Teachers

Once the teacher had made a commitment to participate in the study, schedules for familiarization, videotaping of lessons and SRI's for both teacher and pupils were formulated. Other than the research guidelines for recall enhancement, all schedules were set by the teacher in order to minimize changes in routine as well as inconveniences to the teacher, pupils, or school administrators. At the same time, the researcher carried out an orientation session with the teacher to familiarize him/her with the purpose of the research, the research methodology, and the role of the teacher in the study. Conformity to usual classroom procedures, lesson preparation, and normal classroom behavior was stressed.

A written orientation (Appendix C) providing the teacher with some background to the research project was left with the teacher. Each teacher was asked to raise any questions s(he) might have concerning any aspect of the study. This researcher in answering these questions at various times during the week, emphasized the non-evaluative feature of the study, the significance of such research, and the importance of teacher and pupil participation in educational research.

B. Pupils

Once the pupils to be interviewed were identified, the researcher spoke to each one individually to explain his (her) role in the study. Every opportunity was taken by the researcher to converse with the subjects individually or as part of a group and to answer any questions s(he) might have. Guidelines for conducting pupil SRI's may be found in Appendix D , however this document was translated and used in a different verbal form for communicating the goals of this part of the research project to the pupil. Emphasis was placed on the following aspects:

(1) The SRI is not a memory test or any other kind of test.

(2) How well the student behaves or how well s(he) achieves in mathematics is not the focus of the study.

(3) The pupil should consider the videotaped lesson an ordinary lesson and behave or react as s(he) normally would.

(4) The SRI data is confidential.

During the familiarization phase, a comfortable rapport was established with each pupil to be interviewed. The identity of the pupils to be interviewed was not disclosed until after each lesson had been videotaped, at which time the teacher was informed and then indicated which pupil was to accompany the researcher to the interview room. The decision to choose the pupils to be interviewed after completion of the videotaping was based on guidelines developed during the pilot study. Teachers were less likely to single out these pupils for added attention or to react to them abnormally if they were unaware of who was to be interviewed. Arrangements were made previous to the SRI to have pupils excused from subsequent classes with different teachers.

C. Teachers and Pupils

Both the "Material to be Presented to, and Discussed with the teacher" and"Guidelines for Pupil Stimulated Recall Interviews" were adapted from Marland's (1977) procedures.

Before both the teacher and the pupil SRI, the interviewee was given time to view the videotape and to comment on it as one might in viewing any media display. In fact they were encouraged to do so in order that comments upon their physical appearance and behavioral mannerisms or irrelevant comments about the videotape could be dealt with before the interview started. After approximately ten minutes of viewing, the interviewee was asked if s(he) was ready to view the videotape differently. This time s(he) was asked to immerse himself (herself) in the situation as though s(he) were back in the classroom and to concentrate on recalling his (her) thoughts and feelings. In all cases, the interviewee indicated readiness to devote himself (herself) to the task. Prior to the commencement of the SRI, procedures for initiating dialogue were explained to the interviewee. Since the researcher operated all A-V equipment, the interviewee had only to signal "stop" when s(he) wished to verbalize his (her) recalled thoughts or feelings. In addition, this arrangement left the interviewee free to focus exclusively on his/her interactive thoughts and feelings.

Guidelines for the Interviewer

In addition to establishing a rapport with the interviewee, the verbal and non-verbal conduct of the interviewer during the SRI were considered crucial. To elicit the fullest disclosure of interactive thoughts and feelings and to enhance the quality of recall, the following guidelines were formulated for the interviewer.

(1) Do not make evaluative comments during the interview.

(2) Show a strong interest in what the interviewee is saying.

(3) Do not interrupt the interviewee.

(4) Keep the focus of the interview on task.

(5) Use probing questions when relevant to events on the videotape or to interviewee comments.

(6) Use the words or terminology of the interviewee when phrasing questions.

(7) Avoid all behavior (verbal or non-verbal) which might threaten the psychological safety of the interviewee.

Data and Data Sources

A tabulated format of the data and data sources for this study may be found on page 72.

Preactive Interviews (Teachers)

The interview schedule used was that developed and tested by Marland (1977) (see Appendix A). Although lesson planning as a process was not a focus in this study, it was necessary to obtain information about the instructional plans of the teachers in order to discover their intents even though they might vary during the course of the lesson. As in the pilot study, the decision to obtain this information verbally and record the data yielded more information than would brief planning outlines. At the same time, it provided concrete data for analysis. The two major questions in this schedule asked the teacher to reveal written or unwritten lesson plans and lesson goals.

Professional Data

The Professional Data Questionnaire (see Appendix H) requested minimal information from the teacher. In addition to data including the usual information such as age, teaching experience, teacher professional qualifications, and grades taught in previous years, the teacher was asked to indicate his mathematical background (academic and methods), the subject area in elementary school that he enjoyed teaching most, and the subject area he felt most qualified to teach. These latter items were of major interest to this researcher.

Beliefs about Mathematics and Mathematics Instruction

Two instruments BAMS (Beliefs about Mathematics scale) and BAMIS (Beliefs about Mathematics Instruction scale) developed by Collier (1972) were used to measure the formal-informal dimension of teacher beliefs about mathematics and mathematics instruction. (Appendix G). Both instruments consisted of Likert-type scales which were constructed using a procedure described by Nunnally (1967).

DATA	DATA SOURCES
Videotapes of lessons	Eight lessons ranging from 30-40 minutes were videotaped, two per teacher both in Mathematics.
Interactive information processing data	Stimulated recall interviews were conducted on the same day that the lesson was videotaped with each teacher and two or more pupils. The interviews ranging from 45 minutes to over 2 hours were audiotaped and typewritten manuscripts of these interviews were prepared. (8 with teachers and 20 with pupils).
Preactive plans of teachers	Preactive interviews ranging from 5 to 10 minutes were conducted prior to each of the 8 videotaped lessons.
Teacher presage data	A professional data questionnaire was distributed to and completed by the 4 teachers several weeks after the completion of the videotaping and the SRI's.

DATA	DATA SOURCES
Beliefs held by teachers about mathematics and mathematics instruction	Collier's BAMS and BAMIS instruments were distributed to and completed by the 4 teachers at the same time as the professional data questionnaire.

Methods of Analysis

Stimulated Recall Interviews (SRI's - Teachers)

Both interviews with each of the four teachers were coded using SATIT. A comparison of two different content analysis systems found them to be equally satisfactory for the examination of research constructs. Groupings of categories and/or sub-categories in each system facilitated the examination and interpretation of these constructs. SATIT was used for the micro-analysis of interactive data while a macro-analysis was used to examine the data (interactive and non-interactive) for the following phenomena.

Phenomena

Constraints

Teachers occasionally revealed reasons why they did not pursue alternate courses of action during the lessons taught. The rationales disclosed constituted teacher perceived constraints on their instructional behavior. These constraints were curricular, ecological, temporal or cognitive factors which the teacher perceived as inhibiting his (her) instructional decisions or behavior.

Attributions

Instances in which the teacher attempted to explain why a student was successful or unsuccessful in proffering a correct response, obtaining a correct solution to a mathematical problem, completing a math assignment, or achieving a high mark in mathematics were referred to as attributions. The factors to which a teacher attributed pupil success or failure were classified as external or internal. Internal attributions included factors such as attention span, intellectual competency, or personality characteristics over which the pupil has direct control. External attributions included factors such as noise level, curricular vaugeness, or interruptions over which the pupil had indirect control or no control.

Selective Perception

During the course of the lesson, the teacher revealed awareness interactively and in the stimulated recall data, of certain events that had occurred. These teacher perceptions constituted a small proportion of the totality of actual classroom events and were referred to as selective perceptions. It indicated that the teacher was selective in his/her choice of stimuli to which s(he) attended. The remaining events were either monitored subconsciously or ignored.

Integrative Decision Making

Although teachers make a multitude of interactive decisions during the course of a lesson, the bases for these decisions may or may not be reasoned and deliberated. Indecisions may or may not be reasoned and deliberated. Instructional decision making that was linked to teacher information about pupil affective and cognitive needs or to perceived pupil misconceptions were often revealed in the recall data. When decision making was based on pupil feedback, pupil needs, or a consideration of alternatives, it was referred to as integrative decision making.

Levels of Decision Making

Teacher decisions were basically of two types, those that were made prior to the commencement of the lesson and those made during the lesson. The former were planned and the latter occurred either as a result of the interactions between teacher and pupil (interchanges) or as spontaneous decisions made during the course of instruction (unplanned).

Locus of Control

In reporting satisfaction or disatisfaction with classroom events, teachers frequently attributed success, blame or failure for certain events either to factors outside him/herself and his/her sphere of influence (external) or to him/herself and his/her influence (internal). The balance between these attributions as loci of causality determined the teacher's perception of his/her degree of autonomy in determining classroom events and student states.

Differential Treatment of Pupils

Teachers frequently revealed in the recall data, an awareness of their differential treatment of individual pupils even under seemingly identical circumstances. They disclosed a conscious intent to tailor their behavior to meet what they perceived to be specific needs of individual pupils.

Implicit Theories

The recall data contained statements by teachers which revealed their beliefs about teaching, pupil learning and pupil behavior. These personal perspectives or belief systems about teaching and learning were referred to as implicit theories. Such theories determine instructional behavior to some extent. The congruency between teacher held theories and teaching behavior was not a focus of this study.

Proactive Teaching

Statements made by teachers revealed that frequently their instructional decisions and behavior were guided by preconceived objectives for pupil learning rather than by impluse or reactions to classroom events. Teaching behavior or instructional moves which were not directly related to pupil feedback were referred to as proactive teaching. Such teaching behavior was guided by instructional goals set by the teacher.

Self-Monitoring

Statements made by the teachers often revealed that they were cognizant of pupil reaction to their instructional behavior. Thoughts and/or actions taken by the teacher (reflections and tactical deliverations retrospective) indicated that the teacher was monitoring the impact of his/her instructional behavior on pupils and pupil learning.

Heuristic Strategies

Collective instructional moves which guide pupil thinking strategies and force pupil information processing at higher encoding and decoding levels were referred to as heuristic strategies. Since these were difficult to identify from the recall data, the data was 'sieve' coded for heuristic instructional moves. These moves were classified as instructional moves which serve to guide, discover, or reveal thought strategies (Heuristic Moves A) or instructional moves which force pupils to do their own information processing (Heuristic Moves B).

Basis for Tactical Deliberations-Prospective

In recalling their interactive thoughts about prospective tactical deliberations, teachers frequently revealed the factors upon which they were based. These factors revealed conscious teacher intent to gain pupil attention or interest, to optimize pupil learning, or to be guided by pupil feedback.

Instructional Strategies for Heterogeneous Classes

During the SRI's the teachers revealed individual strategies for coping with a wide range of academic abilities within a class. Such strategies were related to lesson pacing, questioning strategies, lesson content, curricular resources, and ability grouping.

Several of the categories in SATIT were sub-categorized at lower levels of generality for the purpose of macro-analysis.

Stimulated Recall Interviews (SRI's - Pupils)

A content analysis system was developed by this researcher (CAPIT - Content Analysis of Pupil Interactive Thoughts) to analyze and code the data obtained from pupil SRI's. While several systems were devised and subsequent coding of selected transcripts compared, the system chosen

(CAPIT) was considered most suitable for the assumptions underlying the nature of the data and for the purpose of drawing inferences. The following categories were constructed to obtain an exhaustive analysis of the interactive data.

1. Mathemagenic Orientation (MO) - thoughts in which the pupil reports that he has perceived or is perceiving a stimulus relevant to the mathematical content of the lesson.
2. Mathemagenic Encoding I (ME-I) - thoughts in which the pupil reports that he has responded to one or more aspects of the stimulus and was encoding or attempting to encode the mathematical stimulus.
3. Mathemagenic Encoding II (ME-II) - thoughts in which the pupil reports that he has encoded or translated the mathematical stimuli perceived into a personally meaningful form.
4. Monitoring-Self (MS) - thoughts in which the pupil indicates his awareness of and monitoring of his own actions and thoughts during the lesson.
5. Monitoring-Teacher (MT) - pupil thoughts which reflect an attempt to interpret what is going on in the mind of the teacher or pupil reflections on overt teacher behavior.
6. Monitoring-Peers (MP) - pupil thoughts which focus on the behavior of other pupils during the lesson.

NOTE: In categories 4,5, and 6, no explicit reference was made to the mathematical content of the lesson.

7. Information-Relevant (IR) - pupil thoughts which reveal items of information which the pupil possessed prior to the lesson but which are related to events that occurred during the lesson.
8. Information-Irrelevant (II) - pupil thoughts containing information possessed prior to the lesson but bearing no relationship to lesson content or lesson events.
9. Ecological (EC) - thoughts in which the pupil reveals awareness of classroom environmental aspects such as time, temperature, noise, or intercom announcements.
10. Feelings (F) - thoughts in which the pupil reports an affective state experienced during the lesson.
11. Extraneous (EX) - pupil thoughts which are unrelated to lesson content or lesson events but directly related to the irrelevant information proffered by the pupil.

Full details of CAPIT may be found in Appendix F. Sub-categories were constructed for a macro-analysis of this data for the purpose of examining the following phenomena.

Phenomena

Self-Concept

The recall data contained pupil reports of interactive thoughts which revealed beliefs and assumptions about him/herself. Collectively such beliefs constitute a self-concept which serves as a filter for incoming stimuli, an organizer of events, and a guide to appropriate action. A self-concept represents the pupil's interpretation of his/her own strengths, rights, and salient characteristics.

Mathematical Confidence

Statements made by a pupil in the SRI's revealed thoughts about his/her own mathematical competencies. Thoughts which revealed self-perceived strengths and weaknesses relevant to mathematical understanding collectively represented the degree of mathematical confidence.

Locus of Control

On several occasions pupils reported dissatisfaction with certain classroom events or teacher behaviors. Such instances were often perceived by the pupil to be beyond his control or influence. They constituted a pupil perceived locus of control.

Reflective Ability

Pupils frequently reported thoughts which they had about prior classroom events, peer and teacher behaviors, and about their own actions during the lesson. These thoughts collectively represented an ability to reflect upon the past.

Introspective Ability

Statements made by the pupil which revealed an awareness of and a monitoring of his/her own thoughts (during the lesson) were referred to as introspection. The degree to which a pupil monitored his/her own cognitive functioning was indicative of his/her introspective ability.

Mathematical Verbalization

Statements in the recall data frequently contained pupil explanations of mathematical concepts. These statements revealed varying levels of sophistication in pupil ability to verbalize his/her own mathematical thinking.

As in SATIT, an exhaustive category set was used in CAPIT. That is, the system provided for classification of every unit in the interactive data. In the macro-analysis of interactive and non-interactive data, a form of 'sieve' coding was used as a straining device to comb the entire bulk of the data for specific infrequently appearing items. Psychologically meaningful phenomena were extracted from the data by using a conglomerate of sub-categorized items of lower generality.

BAMS and BAMIS

Two instruments were used to measure teacher beliefs about mathematics (BAMS) and teacher beliefs about mathematics instruction (BAMIS). Teachers responded to items in the scales according to a 5 - point interval, from strongly disagree (SD) to strongly agree (SA) as opposed to the 6 - point interval used by Collier (1972). A personal conversation with Collier provided guidelines for this modification and for the use of the scales. There were twenty items in each scale, ten positive and ten negative. The items scored as positive items were those which described mathematics or mathematics instruction as informal. Formal descriptions were scored as negative items. Positive items received the scale value checked as their score (SD-I to SA-5) while negative items received 6 minus the scale value. The item scores were totalled for each scale and each teacher received a BAMS score and a BAMIS score. A score of 60 was interpreted to represent a neutral score; scores greater than

60 were in the 'informal' direction and scores less than 60 in the 'formal' direction.

An ambivalence quotient was also calculated for each teacher on each of the scales. This measure of the ambivalence of beliefs is an index of the level of inconsistency revealed through expressed agreement with both positive and negative items. Of particular interest in this study was the comparison of BAMS and BAMIS scores for each teacher. Such a comparison should reveal whether or not there is any incongruence between teachers' beliefs about mathematics and their beliefs about mathematics instruction. In addition, the relationship between implicit theories revealed in the recall data and teacher responses on these scales was explored.

Reliability and Validity

All teacher and pupil SRI data were coded by this researcher. Both intracoder and intercoder reliability checks were made. Since an intercoder reliability coefficient (.72) in the use of SATIT had been established by this researcher with Marland (1977) in the spring of 1977, intracoder reliability checks were made every second month on selected samples of Marland's data and the pilot study data until the research data was collected. The Marland samples had been coded by Marland and kept for this purpose. The results appear in table 1. For the purpose of obtaining system reliability checks for both CAPIT and SATIT, two graduate students who were trained in the use of these systems coded samples of the research teacher and pupil SRI data. The results appear in table 4.

Scott's formula was used for calculating both intra and intercoder reliability coefficients. It is recommended for use in systems which employ many categories since it yields a conservative coefficient which corrects for the number of categories in the coding system and the frequency with which each is used. Intercoder reliability checks were also conducted in unitizing and in distinguishing interactive from non-interactive data. Guetzkow's (1950) formula was used to establish reliability checks in the unitizing process. Perfect agreement is represented by a coefficient of zero. Results of intercoder reliability for unitizing both CAPIT and SATIT appear in table 4. The formula used for reliability checks on the separation of interactive from non-interactive thought units does not take into account the extent of intercoder agreement which may result from chance. However, according to Holsti (1969), when the number of categories is minimal, this formula yields an adequate reliability check. Perfect agreement is represented by a coefficient of one. Results of intercoder reliability on this separation appear in Table 4.

Guetzkow (1950) suggests guidelines for choosing the unit of analysis. According to him, there are two factors which determine the selection of the amount of material to be included in each unit. (1) The way in which the qualitative material has been gathered and (2) the demands imposed by the category set to be used in classifying. Holsti (1968) considers the most important aspect of this choice to be "that each system .... carries with it a certain set of assumptions regarding the nature of the data and inferences which may be drawn therefrom (p. 649).

Although content validity is normally considered sufficient for purely descriptive research (Holsti, 1968), the problems of validity in content analysis have not been resolved. Since validity is interrelated to the sampling design and reliability, a compromise between high reliability and high validity may sometimes be necessary. For as Guetzkow (1950, p. 142) states, "reliability is a necessary condition for valid inquiry but paradoxically, the cost of some steps taken to increase reliability may be a reduction in validity." Consequently, a balance must be struck between reliability and the relevance of categories or units.

Table 1

Intracoder Reliability on SATIT coding of Marland's data

Interactive Data Categorization

Occasion	Number of Segments Coded	Coefficient of Reliability
1.	60	.81
2.	60	.86
3.	80	.90
4.	80	.89
5.	60	.92
6.	80	.94

Table 2

Intracoder Reliability on SATIT coding of Research data

Interactive Data versus Non-Interactive Data

Occasion	Number of Segments Coded	Coefficient of Reliability
1.	100	.93
2.	100	.92
3.	100	.96

Unitization Occasion	Number of Segments Coded	Coeffieient of Reliability
1	50	.02
2	50	.04
3	50	.03

Categorization Occasion	Number of Segments Coded	Coefficient of Reliability
1	130	.90
2	130	.94
3	130	.93

Table 3

Intracoder Reliability on CAPIT coding of Research data

Interactive Data versus Non-Interactive Data

Occasion	Number of Segments Coded	Coefficient of Reliability
1	40	.95
2	40	.93
3	40	.93

Unitization

Occasion	Number of Segments Coded	Coefficient of Reliability
1	40	.03
2	40	.02
3	40	.01

Categorization

Occasion	Number of Segments Coded	Coefficient of Reliability
1	90	.95
2	90	.92
3	90	.98

Table 4

Intercoder Reliability on Coding of Research data

	Coefficient of Reliability
SATIT Coding	
Interactive versus Non-Interactive Data	
Investigator and Coder 1	.91
Investigator and Coder 2	.85
Unitization	
Investigator and Coder 1	.03 a
Investigator and Coder 2	.06 a
Categorization	
Investigator and Coder 1	.88
Investigator and Coder 2	.77
CAPIT Coding	
Interactive versus Non-Interactive Data	
Investigator and Coder 1	.90
Investigator and Coder 2	.87
Unitization	
Investigator and Coder 1	.02 a
Investigator and Coder 2	.04 a
Categorization	
Investigator and Coder 1	.84
Investigator and Coder 2	.86

a A zero coefficient of reliability for unitization indicates perfect agreement.

In this study, a check was made for internal consistency in the recall data as advocated by Richardson et al (1965). He cites three means of evaluating response validity.

(1) The use of valid external evidence to compare with the response material.

(2) Evidence within the interview such as the inclusion of deliberate questions to provide a validity check with other responses. That is, examine all responses for inconsistencies. This would include examining various overlapping, related or repetitious pieces of information.

(3) Assessment of the style or manner of responses which may indicate respondent motivations for specific responses.

In addition, interview techniques advocated by Maccoby (1954), Cannel and Kahn (1968), and Richardson et al (1965) served as guidelines for increasing the validity of responses.

Structured Interview Questions (Teachers)

Responses by teachers to the structured questions were extracted from the SRI data and comparisons were made.

Similar Nodal Dialogue (Teachers and Pupils)

Responses to probing questions asked by the interviewer at these similar nodes were described, analyzed, and used as a basis for comparing pupil-pupil and teacher-pupil interpretations of the instructional process.

Preactive Interviews (Teachers)

The data obtained from preactive interviews with the teachers was analyzed under the following headings.

(1) Goals/purposes.

(2) Instructional Delivery Systems.

(3) Instructional Strategies.

(4) Content Structure and Sequence.

Assumptions

This investigation of the interactive thoughts of teachers and pupils using introspective methodology was based on the following assumptions:

1. Verbalizations about covert intellectual behavior are reasonably accurate representations of that behavior.
2. The interactive thought processes of teachers are important determinants of teacher behavior during instruction.
3. Teachers and pupils can be viewed as information processors.
4. The major participants in classroom interaction - the teacher and the pupils- constitute important

sources of information in the investigation of the teaching - learning process.

Limitations

The principal limitations of the study are:

1. Samples of schools, teachers, lessons, and pupils were small.
2. Random sampling techniques were not used in the study.
3. Non-standardization of teacher and pupil task environment characteristics.

These limitations preclude making comparisons across the sample or generalizations about individual teachers or pupils.

Chapter IV

RESULTS OF THE INVESTIGATION

Introduction

A micro-and a macro-analysis of all teacher SRI data and pupil SRI data were conducted. The micro-analysis involved the use of two content analysis systems (SATIT and CAPIT) in which all interactive thought units were classified under discrete categories. These categories described specific facets of teacher information processing and pupil information processing. The macro-analysis was based on a type of 'sieve' coding which is not an exhaustive coding system but one by which larger chunks of the recall data containing more than one thought unit can be identified. These larger chunks were then quantified as interactive thoughts indicative of phenomena such as pupil self-concept and mathematical confidence or teacher decision-making levels and teacher perceived constraints. The macro-analysis of the SRI data was not restricted to interactive data.

The results of these analyses are presented in this chapter. The chapter has two sections. Section A contains the micro-and macro-analysis of the teacher stimulated recall data, teacher responses to the Personal and Professional Data Questionnaire and teacher scores on BAMS and BAMIS. Section B contains the micro-and macro-analysis of the pupil stimulated recall data and comparisons of teacher-pupil interpretations of the instructional process.

SECTION A

Stimulated Recall Data (Teacher)

Interactive Thoughts

The content analysis system (SATIT, Appendix C) developed by Marland (1977) was used to analyze the transcripts of the eight teacher stimulated recall interviews (SRI's). Only ten of the categories in this system were used as no units occurred in the 'Fantasies' category. Segments or portions of segments of the protocols comprised of non-interactive teacher thoughts, incomplete teacher thoughts or interviewer interjections were not coded. Table 5 presents as a percentage of the total number of thought units identified in each lesson, the number of thought units in each of the ten categories for each lesson.

The average percentage of thought units in each of the ten categories from the first SRI's were compared with those from the second SRI's. The relative average frequency pattern remained the same. That is in both cases the following results occurred. The largest average percentage of teacher interactive thoughts recalled was prospective tactical deliberations (TD-P First SRI's = 22.5%, Second SRI's = 23.1%), followed by

Interpretations (First SRI's=14.5%, Second SRI's=13.0%)	
Reflections	14.2% + 13.3%
Anticipations	9.1% + 10.0%
Information-Other	9.9% + 9.9%
Perceptions	7.8% + 6.2%
Information-Pupil	7.5% + 8.9%
Retrospective tactical deliberations	7.2% + 6.9%
Goal statements	4.9% + 4.6%
Feelings	2.4% + 2.5%

An examination of individual teacher percentage distributions of thought units revealed that differences existed between teachers and between lessons for the same teacher.

The range in percentages for each category was as follows:

Perceptions	(2.8% - 11.8%)
Interpretations	(8.7% - 21.8%)
Prospective Tactical Deliberations	(17.8% - 30.7%)
Anticipations	(4.8% - 15.4%)
Reflections	(10.6% - 19.6%)
Information - Pupil	(4.3% - 11.8%)
Information - Other	(5.2% - 18.6%)
Goal Statements	(2.2% - 6.3%)
Feelings	(0.7% - 5.2%)
Retrospective Tactical Deliberations	(3.9% - 10.8%)

Table 5

Percentage Distributions of Individual Teachers' Thoughts over SATIT categories for Each Lesson

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math	Math	Math	Math	Math	Math	Math	Math
SATIT Thought Category	% N[a] 415	% 325	% 127	% 146	% 145	% 189	% 214	% 127
Perception	11.5	9.8	6.3	10.3	2.8	5.3	4.7	11.8
Interpretation	19.2	21.8	8.7	19.9	9.7	10.6	14.5	11.8
Tact. Delib. Prospective	18.8	17.8	30.7	19.2	22.8	23.3	20.1	27.6
Anticipation	7.5	10.2	5.5	4.8	11.7	7.9	15.4	9.4
Reflection	10.6	12.6	18.1	16.4	13.8	19.6	11.7	11.0
Information - Pupil	11.8	4.3	8.7	7.5	6.9	3.7	8.4	8.7
Information - Other	7.7	5.2	7.1	9.6	18.6	11.6	11.2	7.9
Goal Statement	4.8	2.2	4.7	6.2	4.8	6.3	4.2	6.3
Feeling	0.7	5.2	2.4	0.7	3.4	2.1	3.3	1.6
Tact. Delib. Retrospective	7.5	10.8	7.9	5.5	5.5	9.5	6.5	3.9
Total %	100.1	99.9	100.1	100.1	100.0	99.9	100.0	100.0

[a] Number of interactive thoughts reported in each stimulated recall interview.

Eight of the ten categories of interactive thoughts were analyzed on the basis of their sustantive components. Six of these used subcategories comparable to Marland's (Perceptions, Interpretations, Reflections, Anticipations, Information-Other, and Feelings). The category, Prospective Tactical Deliberations, was analyzed according to the predominant factor(s) influencing these teacher deliberations.

Substantive Components of Perceptions

The subcategories represent visual and aural cues to which teachers attended during the lessons. The percentage distribution of teacher perceptions in each lesson shown in Table 6 is more revealing if examined in light of the wide discrepencies between the total number of perceptions of teacher A and the other three teachers. The distribution reveals that the teachers were primarily aware of verbal and non-verbal pupil behavior. Teacher A made considerable use of pupil facial expressions as cues upon which to base his (her) estimates of pupil covert cognitive and affective states. Excerpts from several of these thought units include the following.

> ... his eager look ...
>
> ... he was smiling ...
>
> ... they were relieved looking ...

... he's got this funny look on his face that tells me ...

... by the look on his face I ...

... waiting for the looks on their faces ...

... starting to look like he's got a glimmer of ...

... just by her face. She sort of lit up and ...

... their mouths are hanging open ...

... confused just by the look on her face ...)

A further analysis of student verbal and non-verbal behavioral cues revealed that few (about 22%) of these perceptions were non-lesson content related.

Miscues

Several instances of miscuing occurred in these lessons, by either the teacher or one or more pupils.

Teacher Miscues

Teacher miscues consisted of the following:

Lesson B-2: A student cited the different sized circles from which they were to compare different fractions but the teacher interpreted it as a criticism of their differences in circularity.

Lesson C-2: A student (interviewed) offered an answer which another student repeated and for which the latter received credit.

Lesson D-2: Students interjected to correct an error on the board and the teacher interpreted it as an ommission which was also the case. Only the latter was corrected.

Pupil Miscues

Pupil miscues were as follows:

Lesson A-1: (1) Students raised hands to answer a series of questions which the teacher did not intend them to answer.

(2) Students left their desks thinking the lesson presentation by the teacher was finished when in fact it was not.

Lesson C-1: (1) A student (interviewed) felt guilty due to a misunderstanding of contest guidelines.

Lesson D-1: (1) A student (interviewed) interpreted the lesson as a simple review while the teacher saw it as an important transition point.

(2) Same as A-1: (2).

Lesson D-2: (1) A student chose to read a book during part of the lesson although directions had been given to the class before the lesson started to attend to the lesson presentation.

(2) Same as A-1: (2).

While these constituted a very minor part of the total interactions between teacher and pupils, their consequences are relevant.

Consequences of Teacher Miscues

Lesson B-2: The fractions were graphically difficult to compare, did not correspond quantitatively to their respective representations and could have been a source of confusion to some students.

Lesson C-2: The student (interviewed) expressed disappointment which combined with his (her) other recalled thoughts indicated that s(he) viewed him (herself) as a victim of unfairness or bad luck or both.

Lesson D-2: The error, although minor, remained on the board in spite of their attempts to correct it.

Consequences of Pupil Miscues

Lesson A-1: (1) A student (interviewed) who was asked only one question during the lesson, expressed resentment over the teacher answering his(her) own questions while the teacher revealed that the purpose of the tactic was to save time and simultaneously keep the pupils thinking.

(2) The teacher had to send pupils from both grades back to their desks, regain the attention of one grade and then continue the lesson presentation.

Lesson C-1: (1) After months of the same contest, the student (interviewed) was still not sure of the rules. The teacher felt some responsibility for this situation in that the guidelines perhaps had not been explicit enough.

Lesson D-1: (1) The student (interviewed) paid intermittent attention to the lesson and started working on what s(he) assumed the assignment would be. This same student also found it necessary to request individual help with the assignment problems from the teacher at the end of the lesson presentation.

(2) Same as A-1 (2) above with the exception that there was only one grade in the class.

Lesson D-2: (1) The student did not check the assignment answers, was reprimanded by the teacher and subsequently paid attention to the lesson.

(2) Same as D-1 (2) above.

Substantive Components of Interpretations

Based on their perceptions of students, the teachers made inferences primarily about student states of mind. To a much lesser degree they inferred student feelings and student desires, motives or needs (Table 7). Since very little seatwork was engaged in during the filming of these lessons, the absence of units in the category "Student working, not working" was not unexpected. Teacher A made at least three times as many interpretations as did any of the other three teachers in the study. Little or no mention of student motivation during math instruction was made by any of the teachers.

Substantive Components of Reflections

Reflections did not include thoughts about past teacher actions although they did include all other teacher interactive thoughts about prior events in the lesson. The majority of teachers' reflections were about student verbal behaviors and other student behaviors including work products. A considerable proportion of these thoughts were about lesson content and lesson characteristics. Few teacher thoughts focused on time constraints or classroom noise.

Table 8 presents the percentage distribution of teacher reflections by sub-categories.

A further analysis revealed that teacher reflections on non-content related thoughts constituted about ten per cent of all their reflections. That is, the teachers' reflections were predominantly lesson task related while those non-content related thoughts were primarily focused on the psychological dimensions of the interactive process involving affective factors which were implicitly related to the content-related facets of the lesson. These teachers' reflections represented approximately one sixth of all their interactive thoughts compared to one fifth as reported by Marland (1977).

Substantive Components of Anticipations

Teacher interactive thought units classified as anticipations included teacher predictions of future events in the lesson and expectations of students. The former were frequently forecasts of possible consequences of prospective tactical deliberations which were rejected by the teacher. Teacher anticipations were predominantly thoughts about what students might think, say, do, or feel. Approximately one-half of these were about what students might think. A large proportion of these anticipations were expectations of student success or failure at specific points in the lesson. The former constituted twice as many as the latter. Only two teachers revealed interactive thoughts about what they did or did not want to occur. The percentage distribution of these sub-categories appear in Table 9.

Substantive Components of Information - Other

Information brought to the lesson by the teachers formed a part of their information processing and influenced their interactive behaviors. Although information about pupils (Information - Pupil) and several pupil case studies (non-interactive data) appeared in the teacher recall transcripts, only information other than about pupils was analyzed in this category and appears in Table 10 . There were 6 pupil case studies revealed by teacher A, 3 by teacher B, 6 by teacher C, and 4 by teacher D. In all 19 instances, this recall was prompted by instructional moves made by the teacher during the lesson and frequently constituted teacher bases for the differential treatment of pupils. Differential treatment of pupils is discussed on page

While the kinds of Information-Other processed by teachers varied, the majority of this information was about curriculum content, curriculum experiences, teaching principles or style, and beliefs about children. All four teachers recalled interactive thoughts about routinized classroom procedures. Teaching principles or style, beliefs about children and routinized procedures are presented in Appendix K.

Substantive Components of Goal Statements

The average percentage of goal statements found in teachers' recall of interactive thoughts was low (4.9%) but considerably higher than that found by Marland (1977, 2.7%). These statements were sub-categorized as affective and cognitive goals. The latter were analyzed further into three cognitive divisions. These divisions consisted of goals which the teacher had with regard to pupil thoughts or understanding, pupil attention or interest and pupil work. The goal statements were predominantly cognitive and represented more specific goals than those expressed in the preactive teacher interviews. The largest number of cognitive goals were related to pupil thoughts and pupil understanding. All but one teacher recalled affective goal statements that were processed interactively although there was considerable evidence in the non-interactive recall data that this teacher was conscious of pupil affective states. (See Table 11.)

Excerpts of a few of these goal statements (pupil thoughts and understanding) are presented below.

... trying to get them to think beyond that ...

... to think of another way of doing it ...

... to try and get them to think it out ...

... I wanted them to figure that out themselves ...

... I wanted them to think of many different methods for finding the solution...

... I wanted them to understand the relationship of money at that point...

... I wanted the kids to get through to their parents that they (the parents) are doing it a proper way, just different...

Feelings

This category includes all thought units in which teachers recalled emotions experienced during the lesson. Feelings represent the lowest frequency of all thought unit categories (2.4%). The largest number of emotions experienced by any teacher in a single lesson was in A-2. This teacher sensed a general pupil attitude both frustrating and annoying to him (her) which pervaded the first part of the lesson. A number of interruptions also occurred during this same lesson. An announcement about snacks, the return of students from a French lesson, the choice of students to deliver the snacks, all of which necessitated changes in lesson plans by the teacher, may have precipitated more emotional teacher reactions. Five interruptions in lessons A-1 and A-2, and one in lesson D-2 were mentioned by the teachers in the eights SRI's. Although a few short interruptions occurred in a few of the other lessons, they usually occurred either before or near the end of the lesson presentation. The percentage distributions are presented in Table 12.

Substantive Components of Tactical Deliberations - Retrospective

Although these thought units comprised an average of only 7.14% of all recalled interactive thoughts, they represent an important professional function of monitoring one's own actions and their effects upon pupils and pupil learning. These thought units were classified under three sub-categories (See Table 13).

1. Introspection during which the teacher is conscious of and monitoring his (her) thoughts during the lesson.
2. Reflections or interactive thoughts about prior instructional moves without any evaluation of these moves.
3. Evaluations or interactive judgemental thoughts (positive or negative) about prior instructional moves.

Of the 48 evaluative thought units, nearly 73% were negative. That is, these teachers were highly critical of their instructional behavior. An analysis of their external and internal attributions for their success or failure in achieving set goals revealed that in spite of their many perceived constraints to teaching and pupil learning, these four teachers exhibited a 50-50 internal-external locus of control, a somewhat realistic perspective. An analysis of their attributions for pupil success or failure revealed that of the 40 instances cited in the recall data, internality was the predominant attribution. Six attributions for pupil success were cited (6/6-internality) and 34 attributions for pupil failure (22/34-internality, 12/34-externality). A frequent attribution for pupil failure was lack of attention. Other internal attributions for pupil failure included the following.

- has emotional and social problems ...
- they're not as smart as ...
- that's an attitude problem ...
- has difficulty grasping new ideas ...

There were 6 out of the 12 external attributions for pupil failure for which teachers tended to blame themselves and/or their instructional tactics. Not only were these teachers critical of their instructional moves but they also assumed responsibility for pupil misunderstanding, confusion or inability to answer questions correctly.

Basis for Prospective Tactical Deliberations

Of special interest to this investigator was an examination of the factors which influenced teacher prospective tactical deliberations. These interactive thought units were classified under four sub-categories.

1. Optimization of pupil learning: Those teacher deliberations for which explicit confirmation of such an intent was revealed in the SR data as either anticipations or goal statements.
2. Pupil attention or interest: Those tactical deliberations acted upon by the teacher to gain pupil attention or maintain pupil interest.
3. Pupil Feedback: Those tactical deliberations which stemmed from the interactional process and were guided by pupil feedback.
4. Proactive: Those tactical deliberations acted upon by the teacher and upon which pupil feedback seemed to have no bearing nor was there an explicitly expressed teacher intent to optimize pupil learning or gain pupil attention.
5. Miscellaneous: Those tactical deliberations which could not be classified as one of the above four sub-categories.

More specifically, these bases for such deliberations revealed conscious teacher intent. While many of the tactical deliberations acted upon by these teachers could well be classified as 'Optimization of Pupil Learning', this investigator chose not to include these unless the conscious teacher intent to optimize learning was recalled in the SRI protocols.

The highest frequency for these bases was Proactive (Average per cent = 55.4) followed by Optimization of Pupil Learning (Average % = 21.4). These two categories constituted an average percentage of 76.8% of the five bases (See Table 14). To a much lesser extent their prospective tactical deliberations were based on pupil feedback and pupil attention or interest. Although all four teachers were cognizant of pupil feedback, this basis (See Table 14) represents salient points in the lesson at which the teacher consciously altered his (her) immediate tactic to meet specific pupil needs disclosed through pupil feedback, an obvious, though not explicitly stated intent to enhance pupil learning. Of further evidence were 11 instances in which a teacher interactively determined the pace of the lesson, content of the lesson, intermediary success of the lesson and tactics to employ, by using a specific pupil or specific pupils and their feedback as gauges. (See page for a discussion of "Use of Pupils

Table 6

Teachers' Perceptions - Substantive Components - Percentage Distributions

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math	Math	Math	Math	Math	Math	Math	Math
Substantive Components of Perceptions	% N[a] 48	% 32	% 8	% 15	% 4	% 10	% 10	% 15
Student verbal behavior (work related questions, answers, comments	39.6	31.3	25	66.7		70	30	40
Student non-verbal behavior A-Movement, posture position	37.5	37.5	62.5	26.7	75	20	60	53.3
B-Expressions glances, laughter	8.3	18.8		6.7				
Student work, work activity (working, not working, written work	2.1	6.2			25	10		

[a] Number of perceptions in each lesson.

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Table 6 (continued)

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Curriculum material	4.2						10	
Classroom noise	2.1							6.7
Miscellaneous	6.3	6.2	12.5					
Total	100.1	100.1	100.1	100.1	100.0	100.0	100.0	100.0

[a] Number of perceptions in each lesson.

Table 7

Teachers' Interpretations - Substantive Components - Percentage Distributions

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math	Math	Math	Math	Math	Math	Math	Math
Substantive Components of Interpretations	% N[a]80	% 71	% 11	% 29	% 14	% 20	% 31	% 15
Student states of knowledge, thoughts, thought processes	83.7	78.9	81.9	79.3	85.7	75	83.9	86.7
Student desires, motives, needs	11.2	9.8	9.1	10.3	7.1	10	6.5	6.7
Student aspirations, goals	3.7			6.9				
Student motivation for classroom work	1.3	1.4						
Student feelings		9.8	9.1	3.4	7.1	15	9.7	6.7
Student working, not working								
Miscellaneous								
Total	99.9	99.9	100.1	99.9	99.9	100.1	100.1	100.1

[a] Number of interpretations in each lesson.

Table 8

Teachers' Reflections - Substantive Components - Percentage Distributions

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math	Math	Math	Math	Math	Math	Math	Math
Substantive Components of Reflections	% N[a] 44	% 41	% 23	% 24	% 20	% 37	% 25	% 14
Student Verbal behaviors (comments, question, responses)	38.6	29.3	13	50	25	40.5	36	21.4
Other student behaviors, characteristics, work	27.3	43.9	65.2	29.2	65	35.1	36	50
Lesson content characteristics	22.7	12.2	17.4	12.5	10.0	18.9	24.0	21.4
Classroom atmosphere, noise	6.8	2.4		8.3				7.1
Time		9.8				2.7		
Miscellaneous	4.5	2.4	4.3			2.7	4	
Total	99.9	100.0	99.9	100.0	100.0	99.9	100.0	99.9

[a] Number of reflections in each lesson.

Table 9

Teachers' Anticipations - Substantive Components - Percentage Distributions

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math	Math	Math	Math	Math	Math	Math	Math
Substantive Components of Anticipations	% N[a] 31	% 33	% 7	% 7	% 17	% 15	% 33	% 11
What students might say, do, think, feel	45.2	21.0	28.6	42.9	70.6	46.7	60.6	54.5
Student success	19.4	27.3	42.9	42.9	23.5	26.7	15.2	18.2
Student failure, delay, confusion in work related activities	9.7	15.2	28.6	14.3		26.7	9.1	9.1
Students' future needs, wants, interests, etc; (as perceived by teacher)		9.1			5.9			
Problems likely to arise e.g., disorder, pupil inactivity, delays	3.2	3.0						
Other classroom events likely to occur, events the teacher wanted or did not want to occur	19.4	18.2					15.2	18.2

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Table 9 (continued)

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Miscellaneous	3.2	6.1						
Total	100.1	99.9	100.1	100.1	100.0	100.1	100.1	100.0

[a] Number of anticipations in each lesson.

Table 10

Teachers' Use of Information-Other - Substantive Components - Percentage Distributions

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math	Math	Math	Math	Math	Math	Math	Math
Substantive Components of Thought (Information-Other)	%	%	%	%	%	%	%	%
N[a]	32	17	9	14	27	22	24	10
Curriculum content	18.8	35.3	33.3	50	3.7	9.1	16.7	40
Lesson plans		17.6			3.7		8.3	30
Curric. experiences	12.5	11.8	11.1	7.1	25.9	13.6	8.3	
Extra-curr. experiences								
General knowledge	12.5	5.9		28.6		9.1		
Knowledge about school, comm.	3.1							

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Table 10 (continued)

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Classroom resources								
Teaching principles, style	6.3	11.8	11.1	7.1	25.9	36.4	25	20
Beliefs about children	15.6		22.2	7.1	18.5	18.2	29.2	
Routinized	6.3	5.9	11.1		22.2	13.6	8.3	10
Miscellaneous	25	11.8	11.1				4.2	
Total	100.1	100.1	99.9	99.9	99.9	99.9	100.0	100.0

[a] Number of thoughts in Information-Other category in each lesson.

Table 11

Goal Statements
Substantive Components - Percentage Distributions

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math %	Math %	Math %	Math %	Math %	Math %	Math %	Math %
Substantive Components of Goal Statements	N^a 20	7	6	9	7	12	9	8
Affective	25	14.3	33.3	22.2		16.6		
Cognitive								
Pupil thoughts, understanding	50	28.6	33.3	66.6	85.7	83.3	55.5	62.5
Pupil attention, interest	15	42.9					22.2	12.5
Pupil work	10	14.3	33.3	11.1	14.3		22.2	25
Sub-total	75	85.8	66.6	77.7	100.0	83.3	99.9	100.0
Total	100.0	100.1	99.9	99.9	100.0	99.9	99.9	100.0

[a] Number of goal statements in each lesson.

Table 12

Teachers' Feelings - Substantive Components - Percentage Distributions

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math &	Math &	Math &	Math &	Math &	Math &	Math &	Math &
Categories	N[a] 3	17	3	1	5	4	7	2
Anxiety, concern			33.0				14.3	
Frustration, disappointment, annoyance, dissatisfaction, displeasure		35.3	33.3			75.0	42.9	
Pleasure, delight	66.7	11.8			20.0			
Surprise, dismay, amazement, puzzlement		17.6			40.0	25.0	42.9	100.0
Equanimity, tolerance	33.3	23.5	33.3	100.0				
Feelings of disorganization					40.0			
Sympathy		5.9						
Foolishness		5.9						
Total	100.0	100.0	99.9	100.0	100.0	100.0	100.1	100.0

[a] Number of occasions teachers reported feelings in each lesson.

Table 13

Tactical Deliberations (Retrospective) - Substantive Components - Percentage Distribution

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math	Math	Math	Math	Math	Math	Math	Math
Substantive Components of TD Retrospective	% N^a 31	% 35	% 10	% 8	% 8	% 18	% 14	% 5
Intro-spection	6.5	5.7						
Reflection	71	51.4	60	62.5	37.5	55.5	71.4	60
Evaluation	22.6	42.9	40	37.5	62.5	44.4	28.5	40
Total	100.1	100.0	100.0	100.0	100.0	99.9	99.9	100.0

[a] Number of retrospective tactical deliberations in each lesson.

Table 14

Tactical Deliberations (Prospective) Bases for - Percentage Distributions

Teacher-Lesson	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Grade	4&5	4&5	6	6	4	4	5	5
Subject Area	Math	Math	Math	Math	Math	Math	Math	Math
	%	%	%	%	%	%	%	%
Bases for Tactical Deliberation (Prospective)	N[a] 78	58	39	28	33	44	43	35
Optimization of pupil learning	19.2	25.9	20.5	14.3	36.4	38.6	16.3	22.9
Pupil attention, interest	7.7	3.4		3.6	3.0	2.3	13.9	8.6
Pupil feedback	9.0	12.1	10.3	17.9	15.2	13.6	2.3	2.9
Proactive	61.5	50	66.7	64.3	39.4	45.4	67.4	48.6
Miscell-aneous	2.6	8.6	2.6		6.1			17.1
Total	100.0	100.0	100.1	100.1	100.1	99.9	99.9	100.1

[a] Number of prospective tactical deliberations in each lesson.

as Gauges"). Although levels of decision making did not constitute a focal point of this study, a discussion of unplanned versus planned instructional activities is presented on page

Macro-Analysis

The following phenomena were revealed in the SR data although several of these were not anticipated initially by the investigator. In contrast to the previous analyses, both interactive and non-interactive recall data were used as a basis for this macro-analysis.

1. Differential Treatment of Pupils
2. Instructional Constraints
3. Use of Pupils as a Gauge
4. Levels of Decision Making
5. Training Effects
6. Additional Pupil Information (Non-interactive)
7. Additional Information (Non-interactive)
8. Teaching Styles
9. Implicit Theories
10. Heuristic Instructional Moves and Strategies
11. Case Study (Lesson C-2)

Differential Treatment of Pupils

There were 32 instances of this phenomenon in the SR data (Teacher A=17, B=4, C=3, and D=8). These different treatments were revealed in relation to tactics which the teacher used or did not use because of teacher perceived individual pupil needs or problems. These phenomena were related to tactics designed to accommodate the affective or emotional needs of certain pupils, to circumvent unwanted situations which had previously arisen due to specific cognitive and affective pupil problems, to inculcate a new student into routinized classroom procedures, to compensate for weak and to counteract strong pupil self-images, to accommodate pupil differential cognitive levels, to balance pleasant and unpleasant pupil classroom experiences, to compensate for personality traits such as shyness, fear, or laziness, to control the number of dyadic interactions between the teacher and bright students through avoidance or aversion, and to compensate for pupil physical defects. The following principles and teacher tactics describe the ways in which teachers exhibited differential treatments of pupils.

A. The Principle of Compensation

Teachers deliberately and consciously compensated for teacher perceived pupil personality traits and physical defects. Three of the four teachers disclosed the former and one teacher the latter. Tactics employed to this end included the following.

1. Frequent tactics to check on the attention of one pupil who sat in a front desk because of a hearing defect.
2. Tactics to provide non-threatening interactional situations as well as semi-private pupil initiated dyadic contact with the teacher whenever requested.
3. Tactics to force lazy students to tackle their work and to do their own information processing without help from other students or the teacher.

B. The Principle of Accommodation

All four teachers disclosed deliberate and planned accommodation tactics for differential pupil levels of cognitive development and emotional maturity. The following tactics were employed.

1. Tactics to accommodate
    a. attention spans,
    b. abilities to answer high level questions,
    c. reflective and impulsive thinkers,
    d. abilities to engage in curtailed reasoning,
    e. mathematical verbal skills.
2. Tactics to accommodate
    a. needs for extra attention,
    b. abilities to tolerate jesting,
    c. abilities to face failure with equanimity,
    d. abilities to accept corrections or constructive criticism without embarrassment.

C. The Principle of Aversion

This principle of aversion or avoidance was exhibited explicitly by two teachers and implicitly by one.

These teachers revealed that while they attempted to direct questions to all pupils in the class, they avoided asking certain students because they thought these students would always have the correct answers. One teacher disclosed in an SRI that s(he) felt it was unfortunate that they didn't receive more attention during instruction. A discussion of teacher interaction with bright students is contained in the topic "Coping with Heterogeneous Mathematics Classes" on page

D. The Principle of Circumvention

Preventing unwanted situations, both affective and cognitive, through circumvention was disclosed by all four teachers. Their expertise in facilitating desirable learning conditions and maintaining lesson flow was due in part to their extensive knowledge of their pupils and also to their knowledge of and ability to implement tactics related to this principle. These tactics included those designed to

1. minimize incorrect pupil responses,
2. prevent pupil difficulties with seatwork and assignments,
3. minimize distractors to lesson objectives,
4. eliminate negative attitudes toward mathematics,
5. avoid situations threatening to pupil self-image,
6. prevent emotional reactions and disruptions,
7. eliminate factors that inhibit mathematical con-

fidence.

The remaining three principles were exhibited by one teacher only.

E. The Principle of Unobtrusive Orientation was related to tactics employed by the teacher to orient a new pupil to classroom procedures. Rather ironically, this student elicited undue teacher interaction through inattention which posed the question of whether private orientation by the teacher might not have been more appropriate in this case.

F. The Principle of Balancing pleasant and unpleasant pupil experiences in the classroom was exhibited frequently by the teacher and constituted a significant attribute in view of the fact that it occurred within a single lesson as well as from one lesson to another.

G. The Principle of Levelling involved teacher tactics to improve the self-concept of several pupils. For pupils who were reluctant to answer questions or who had difficulty articulating correct responses the teacher took the time to ensure that they achieved some degree of success. In one case the teacher consciously employed tactics to prevent any enhancement of the pupil's self-concept.

This levelling of pupil self-concept was generally from low to higher but the case in which it was from high to lower presented a puzzling phenomenon to this investigator.

In the latter case, it involved an extremely bright student whose unmet emotional needs were disclosed in a SRI.

In contrast to Marland's study, only one of the 5 principles he cited (Compensation, Strategic Leniency, Power Sharing, Progressive Checking, and Suppressing Emotions) was exhibited in this study. However, in the pilot study, both the principle of Strategic Leniency and the principle of Power Sharing were evidenced.

Constraints

A number of factors cited by the teachers constituted teacher perceived constraints to their instructional flexibility and instructional effectiveness. Teacher A cited 18 factors while the remaining three teachers cited the same number collectively. Ecological constraints commonly cited were spatial, temporal, disruptive, organizational, and cognitive although they are interdependent. The cognitive constraints perceived by the teachers were of special interest to this investigator. These were categorized as teacher perceived *teacher* cognitive constraints and *pupil* cognitive constraints, as follows:

A. Teacher Cognitive Constraints

1. Adapting lesson content and pace to varying levels of pupil cognitive development.
2. Not aware of pupil thought processes.

3. Pupils can temporarily deceive teachers about their understanding of concepts taught.
4. Disciplinary and/or disruptive factors either usurp relevant information processing space or cause information overload.
5. Inability to monitor two groups simultaneously.
6. Inability to effectively teach certain concepts in mathematics.

B. Pupil Cognitive Constraints

1. Pupil non-use of relevant information in math problems.
2. Inability to verbalize their mathematical thinking.
3. Inadequate listening skills.
4. Pupil aversion to using new and/or different methods for solving problems.
5. Pupils who are not independent thinkers or workers.
6. Pupil proffered examples inappropriate to lesson objectives.
7. Pupil inability to choose the most effective methods for solving problems.
8. Mental laziness.

One teacher stated that perhaps one adverse effect of television viewing on pupils is that it contributes to mental laziness, "it's kind of spoiling them. I don't think they think as well as they used to. They don't know how to entertain themselves internally. It always comes from the external in."

The semi-structured questions did not include a focus on teacher perceived constraints nor were interviewer probing questions directed at this area. As for possible means of eradicating these constraints, few suggestions were proffered by the teachers in the recall data.

Use of Pupils as a Gauge

All four teachers in this study used individual students or sub-groups of students in the class to gauge their lesson flow and lesson pace. There were 11 instances disclosed in the SR protocols although teacher A cited four of these. Bright students were used

1. to quicken the pace of the lesson by providing correct answers succinctly.
2. to provide a peer teaching function through helping other pupils with seatwork and through answering higher level questions correctly.
3. to gauge whether further explanation or multiple embodiment was needed.

Slower students were used

1. to gauge the class understanding of a concept.
2. to gauge the pacing of the lesson and the quantity of content to be presented in a lesson.

Average students were used individually and collectively to gauge lesson pace particularly when economy of time was essential. Teachers were cognizant of students who were quick to grasp and those who were slower at grasping new concepts and planned re-teaching or reviews of concepts to ensure future understanding. Teachers also provided flexible guidelines for pupil choice of different methods of solution but were largely guided by the abilities of their average students in their lesson presentations.

Levels of Decision-Making

The prospective tactical deliberations of the teachers were analyzed to determine the levels of decision-making. A noticeable characteristic of those specific points in the lesson when teachers rapidly weighed alternatives as that invariably they consisted of 'either-or' choices. That is, only two courses of action were contemplated and one rejected although collectively they represent a multitude of alternatives. What was not apparent was whether the~~se~~ teachers were consciously aware of their teaching styles which these collective decisions represent.

The prospective tactical deliberations acted upon by the teachers during the lesson and revealed in the interactive recall data were classified as *planned*, *interchange*, and *unplanned* decisions. Of the total number of decisions made, *20* unplanned decisions were made in eight lessons

(Teacher A=11, teacher B=2, teacher C=1 and teacher D=5). These unplanned decisions were based on feedback from students in the form of unsolicited pupil comments or questions, student difficulties with lesson content, and student proffered examples and problems to be solved. In no instance did any teacher depart abruptly or radically from planned activities.

Training Effects

Non-interactive SR data provided 15 instances of teacher reactions to and/or assessment of feedback obtained through viewing the videotaped lessons, which were indicative of their potential for pre and inservice training of teachers. At certain points in the SRI's, these teachers deviated from the purpose of the interview to consider and evaluate lesson events admitting at the same time that these thoughts were not interactive. It was all the more surprising given the completely non-evaluative nature of the study. Teacher A revealed 11 such effects and the other three teachers revealed 4 collectively (B=2, C=1, and D=1). While the duration of most teacher SRI's ranged from 1 hour to 1 and a half hours, teacher A's SRI's each lasted approximately two hours. This teacher did not have immediate subsequent commitments and came to the interview prepared to spend as much time as it took to view the videotape lesson and reflect in detail upon his (her) interactive thoughts.

Of these 15 instances, six were related to observations of pupils which caused the following teacher reactions.

(a) the teacher assumed that two students were listening to the lesson presentation but could infer from viewing their sequential actions on the videotape that they were experiencing a dilemma and in all probability were not listening.

(b) the teacher assumed in the lesson that the students could see the concrete demonstration of equivalent fractions but realized from the videotape that a number of students were probably too far away to count the rectangles.

(c) the teacher noticed on videotape that a student had raised a hand twice for a tally of which of two methods was used to solve a problem, an event that during the lesson resulted in a miscount. S(he) pondered why other pupils who had used both methods had not raised a hand twice, a consequence which s(he) had not anticipated during the lesson.

(d) the teacher confirmed his (her) interactive impression that a student was not behaving normally during the lesson and attributed it to the presence of the camera in the room.

(e) the teacher observed that a classroom rule (split grade) barring pupil interruptions of teaching except in an emergency resulted in a number of students, "waiting like vultures" to ask questions. The teacher comment was, "I never thought of that till now. If they have to go to the washroom I guess they're afraid to ask me at that time."

(f) Similiar to (e), a student had waited about 10 minutes to inform the teacher about her mother's presence at the door. The teacher commented, "I must have really reinforced that."

Six of these teacher reactions were related to observations of their own behavior.

(a) the teacher noted the higher voice volume used in his (her) teaching, a phenomenon which occasionally resulted in a temporary carry-over to non-instructional situations as previously remarked upon by the school secretary. S(He) evaluated this behavior positively.

(b) A teacher commented, "I notice I'm always writing on the board.", but evaluated this behavior positively.

(c) After viewing a sequence of questions and no answers from the pupils, the teacher remarked, "I was awfully easy on them." but concluded that s(he) must have been thinking that they just need more time on the concept.

(d) After viewing the number of pupil hands up (to answer questions) that had been ignored, the teacher commented on the unfortunateness of the occurrence and concluded that the slower students get more turns to answer than the others.

(e) After a short dialogue in the SRI regarding mathematical terminology used in the lesson, the teacher remarked, "Actually I should have a closer look at what they have to learn next year.".

(f) This last instance involved an astute observation and recognition of teacher body language, an illustration of this teacher's strong cooperative commitment to the study and a pervading intent to treat his (her) part in it as a learning experience. It involved a teacher initiated private teacher-pupil contact. The pupil was perceived by the teacher to have social and emotional problems which created academic problems for him (her). An outburst had occurred in this investigator's presence prior to the day on which the lesson was filmed. The following dialogue was teacher initiated.

T: "He doesn't get much good news from me ... so I rush off to tell him something good. And then at the same time he asks me for help with his work.

> When I come to _____, I mean I'm just looking at the body language part, what I'm actually looking like. I come to tell him something good, ah, almost playing up to what he needs and I put myself at a lower level than him which shouldn't have been necessary. But I must have done it for some subconscious reason. And then as soon as he asks me for help with the question, I stood up whereas I could have just stayed squatting. Now why did I do that? I don't know .... "

I: "It's making you wonder now?"

T: "Yeah. As soon as he asked me a question, I stood up, like okay, I'm the teacher now. I don't know, funny ay?"

The remaining three instances involved teacher observation of pupil behavior relative to simultaneous teacher behavior.

(a) the teacher observed pupil miscuing in response to a questioning technique in which the teacher intent was not to elicit verbal pupil responses. S(He) commented, "You can do that too much of course.".

(b) the teacher observed a pupil hand up for some time and which was eventually lowered without teacher response to it. S(He) made the comment, "It shows me ... I was going on too long and not looking back at the class to see if anybody has any questions.".

(c) the teacher observing a pupil response behavior was critical of his (her) questioning technique. The teacher remarked, "I asked them too soon and I don't really give them enough time to even think about it. And I think they feel pressured... I try to (give them enough time) but there you see, I'm guilty of it.".

Additional Pupil Information (Non-Interactive)

Although the information about pupils proffered by teachers during the SRI's included case studies of pupils (classified as non-interactive) and 'information-pupil' interactive thought units, a number of non-interactive thought units about pupils which were not lengthy enough to be classified as case studies were revealed. These statements were 'asides' to the interviewer and in some cases teacher attempts to explain, justify, or rationalize his (her) own actions although they were not proffered in a defensive manner. This information consisted of teacher knowledge and assessments of individual pupils or groups of pupils. Several of these are noted below.

1. Of a pupil who did seem to demand and receive a disproportionate amount of attention, one teacher made the comment, "He needs a lot of attention ... although I don't pick him all the time of course. Lots of times I do it (pick him) to get it over with.".
2. Of two female students who were interviewed and of whom the teacher made a conscious decision about half way through the lesson to ask questions because of their participation in the study, the

following teacher comments were made.

> "They're both such good students ... both cooperative. They're not the type who if I'd left them out, it would really matter. So I might leave them out a little more normally."

3. One teacher compared the pupils' interactive group behavior in a split class and proffered reasons for these differences but prefaced her remark by, "You can see...
4. Although four pupils in one grade in a split class were not included in the study, the teacher revealed information about their group behavior.
5. Two teachers analyzed the mathematical competencies of their classes. Teacher C estimated that the average ability of her pupils was above average while teacher B estimated that approximately two-thirds of the students were average or weak in mathematics.

Additional Information (Non-Interactive)

In addition to interactive thoughts about pupils and a host of other relevant areas, teachers also disclosed information about the following:

1. Their use of curricular materials and resources.
2. Routinized classroom procedures.
3. Curricular experiences.

4. Curriculum requirements.
5. Interactions with parents and parental assistance.
6. Teaching styles.

While much of this additional information was confirmed through investigator observation, no attempt was made to empirically verify it. 6

Teaching Styles

Through the analyses of both interactive and non-interactive SR data, many instances of individual teaching styles emerged. However, the basis for including these in the study was not inferential. The instances (Appendix K) are paraphrases of teacher statements which were made during the SRI's. There were 32 instances revealed (Teacher A= 7, B= 3, C= 17 and D= 5). No attempt was made to categorize teaching styles as the study was not designed for this purpose.

Implicit Theories

The SR data contained many teacher beliefs about teaching and learning. Although these were not necessarily consciously processed interactively by the teacher, they constitute sets of implicit theories which are reflected to varying degrees in teaching behaviors. The degree of consistency in this reflection was not a focus of this study.

A total of 112 beliefs about teaching and learning were disclosed by the four teachers (Teacher A=26, B=25, C=46 and D=15). Teacher implicit theories are presented in Appendix K.

Heuristic Instructional Moves and Strategies

For the purpose of this study, heuristic moves and heuristic strategies were differentiated and the former classified as heuristic moves A and B as follows:

Heuristic Moves A: Instructional moves which serve to guide, discover, or reveal, relative to pupil information processing.

Heuristic Moves B: Instructional moves which force pupils to do their own information processing.

Heuristic Strategies: Collective instructional moves which guide pupil thinking strategies and force pupil information processing at higher encoding and decoding levels.

Table 15 presents the number and distribution of heuristic moves revealed by each teacher during the two SRI's.

Table 15

Teacher	No. of Heuristic Moves SRI-1 A	No. of Heuristic Moves SRI-1 B	Total No. of Heuristic Moves
A	4	6	10
B	1	4	5
C	7	23	30
D	2	12	14
	14	45	59

These heuristic moves represent only those moves made with conscious teacher intent and recalled during the SRI's. They are not representative of the totality of such moves which could be identified through analytical observational techniques. The heuristic moves A identified in the protocols consisted of the following:

1. Mathemagenic prompting: Prompting which provides guidelines for pupils thinking strategies but which do not provide the response as is the case in 'response prompting'.
2. Concept presentation which elicits inductive reasoning.
3. Teacher cross linkage of concepts for pupil encoding which also included learning transfer.
4. Teacher synthesis of algorithm steps.
5. Teacher control of distractors during problem solving.
6. Teacher control of content specifics in pupil proffered problems to be solved.

The heuristic moves B identified in the protocols consisted of the following:

1. Pupil preliminary estimation of problem solutions.
2. Divergent questions.
3. Pupil oral construction of verbal problems.
4. Non-numerical verbal pupil responses required.
5. Intentional teacher errors in lesson presentation.
6. Variety of problem-solving methods presented.
7. Pupil choice of problem solving method required.
8. Pupil anticipation of teacher questions expected.
9. Intentional pacing of teacher questions to allow for different pupil cognitive styles.
10. Prevention of rigidity in pupil thought processes.
11. Planned sequencing and mixing of higher level questions.
12. Pupil speculation required.
13. Functional relevance in teacher choice of problem contexts requiring additional pupil information processing.
14. Teacher elicitation of maximum levels of pupil information processing capacities.
15. Pupil trial and error methods required.
16. Teacher refrained from prompting (Mathemagenic or Response).
17. Pupil curtailed mathematical reasoning accepted by teacher.
18. Pupil understanding and verbalization of process required.

19. Pupil flexibility in solution format required.

Heuristic strategies are difficult to identify from SR data since they consist of sequential combinations of heuristic instructional moves which occur during short intervals of instruction or global strategies which are pervasive over longer intervals of instruction, a whole lesson or several lessons. Because of the high incidence of heuristic moves in lesson C-2, it is the only one in which this investigator has identified heuristic strategies. These are discussed in the case study. (Appendix L).

Comparison of Teacher Response to Semi-Structured Questions

During the second SRI each teacher was asked a series of questions by the interviewer. Collectively these questions probed for teacher conceptualization of mathematics and instructional moves which reflected that conceptualization. Teachers were informed of this procedure during their orientation and immediately prior to their second SRI. They were also requested to recall interactive thoughts and feelings. To minimize interference with teacher recall, six questions were asked at the conclusion of the interview and the remaining twelve questions were asked intermittently throughout the SRI. To maintain the natural flow of recall and dialogue these 12 questions were not asked in any consistent sequence. The question might opportunely arise as part of the dialogue in a teacher initiated segment and in a few cases the teachers' recall answered the question without it being asked. The remainder of the 12 questions were posed in interviewer initiated segments. As a consequence, not all of the questions were asked of all the teachers; however a total of 74 questions chosen from the twelve intermittent questions were asked of the four teachers. These 74 questions and the teacher responses provided a basis for comparison.

Teacher Responses to Semi-Structured Questions

Question 1(a) Why did you introduce this concept in that manner?

Responses:

Teacher A: "The text provided a good review as well as the introduction of a new concept."

Teacher B: "I've used this method for the last five years and find it best." (Introduction of fractions on the board using diagrams.)

Teacher C: "Because understanding and being able to use a method is more important than which method you use." (Teacher taught a new method and compared it to the old method previously taught.)

Teacher D: "I used the same method as the text provided." (Teacher presented the lesson on the overhead projector.)

Question 1(b) Why did you use those terms of reference?

Responses:

Teacher A: "They've heard the term before and know what it means. Understanding mathematical terminology is a math skill. Too many math terms can be cumbersome and a hindrance to understanding."

Teacher B: "So pupils know, understand, and use math terms."

Teacher C: "To build student math vocabularies which will enable them to express themselves.

Question 1(c) Do you think that the students had the mathematical knowledge and skills to understand the new concepts?

Responses:

Teacher A: "The majority of them should have but a few needed more explanation."

Teacher B: "Yes they did. I checked with their teacher in the previous grade to see what concepts had been covered and the time spent on fractions."

Question 2(a) Why did you use that (those) example(s)?

Responses:

Teacher C: "The contexts of the problems were those with which they were already familiar and understood. Introducing too many new situations makes it difficult for them to concentrate on the new concept being taught."

Teacher D: "By working with a number of different common denominators they will see the inconvenience and the difficulties in working with large denominators and understand why we choose the lowest common denominator. The LCD is the most efficient way."

Question 2(b) Why did you sequence the examples in that manner?

Responses:

Teacher A: "The initial sequence was given in the text but I wanted something quite simple but different from those in the text to see if they understood."

Teacher B: "I deliberately started with the simplest fraction and progressed to the more unfamiliar and difficult fractions."

Teacher C: "By showing both methods they would be able to draw analogies. The concept was more meaningful although the methods were very similiar when true estimates were used (Partial Quotient Method). By not introducing a new problem type they would feel more secure with the new method."

Question 3(a) Why did you use that format?

Responses:

Teacher C: "It was not intentional but somewhat sloppy. I use a consistent format to improve their estimation skills."

Teacher D: "To show that both types of answers are correct. It's important to include correct format in the solution and the answers to problems. Different formats or ommission of format can be confusing to some students but not to the brighter students who already have a good understanding."

Question 3(b) Do you think the students understood that format?

Responses:

Teacher A: "I'm not sure so from here on I'll have to teach it again or give some more examples."

Teacher B: "Yes, I find it usually is the best way.

Yes they did, as most students were able to complete their assignment during the lesson."

Teacher C: "It may have been confusing to some so I should have used poor estimates (which the teacher did later on).
I think they did."

Teacher D: "Some would initially and later they all would since it provides versatility.
Some would but after more examples they all should."

Question 4 (a) Why did you ask that question?
This was never asked by the interviewer.

Question 4(b) Why did you ask _____ that question?

Responses:

Teacher A: "To get him to pay attention.
Because she lit up like she knew the answer.
Because she hadn't had a turn yet.
I was pretty sure she was watching.
To keep him interested in the lesson.
He didn't have a look on his face that meant he knew what we were talking about."

Teacher B: "I just pick them randomly and usually spot someone's eyes that show they're paying attention."

Teacher C: "He wasn't paying attention.
I wanted a correct response."

Teacher D: "He didn't get a question like that the previous day and I wanted to see if he was more able to get it today.
He would be able to do it correctly and also to explain it.
Because he had chosen the denominator.
I wanted to see who was able and felt confident enough to answer."

Question 4(c) Was the student using the right method to solve the problem?

Responses:

Teacher D: "She was adding instead of subtracting."

Question 4 (d) Why did you ask someone else that same question?

Responses:

Teacher B: "It's pointless to keep after them if they don't know the answer."

Teacher C: "To give as many kids as possible a chance to answer."

Teacher D: "It did not serve a constructive purpose to labor over it."

Question 4(e) Are the students able to verbalize their mathematical thinking?

Responses:

Teacher A: "Some are more capable than others."

Teacher C: "I give them practice so they'll get better at it since it's important for kids to be able to verbalize the situation."

Teacher D: "Some are able to but others don't get much beyond rote memorization."

Question 5(a) Do you ever use a different approach and if so, why did you use this one?

All four teachers indicated that they had used different approaches to teach the same concept but two teachers felt that certain constraints (Curriculum resources and a split class) restricted their flexibility. Two teachers may have interpreted the question differently as their answers were given in terms of the use of manipulative materials versus their non-use. The approach used by one teacher was chosen because of past success with it.

Question 5(b) Why do you use more than one approach?

Two teachers mentioned the need for a variety of approaches. One of these stated that s(he) and the pupils like variety and s(he) uses any approach that s(he) finds successful. A third teacher stated that "you change it when you're not getting results - it depends on the pupils.". The fourth teacher said that the approach taken depends upon the different age levels and the pupils' need for concrete experiences.

Question 6(a) Would you classify your method as inductive
or deductive?

Two teachers classified their approach taken in the videotaped lesson as deductive. One said that the approach taken was a little of both, while the fourth teacher perceived the initial part of the lesson as inductive and the latter as deductive. Through observation, this investigator would agree with their respective classifications.

Question 6(b) Do you tend to use one method more than the
other, and if so, why?

Responses:

Teacher A: Uses deductive primarily. S(He), through past experience concluded that the students in that class were not good at inductive reasoning.

Teacher B: Used both. This teacher stated that it depends on the unit and the lesson being taught. S(He) uses inductive methods to teach new concepts and deductive to teach concepts with which the students are already familiar.

Teacher C: Uses both. This teacher said that s(he) would need to analyze the methods used before s(he) could answer the question but stated that, "I encourage them to think for themselves.".

Teacher D: Uses deductive primarily. This teacher stated that s(he) generally follows the approach taken by the teacher's manual.

Question 7(a) Do you teach strategies for problem solving and if so, why?

Responses:

Teacher A: Teaches strategies for certain skills because it makes it easier to learn.

Teacher B: "Problem solving is an area they must know but they have difficulty with it. The bright students evolve their own strategies for attacking math problems."

Teacher C: "Problem solving is my current bone to work on .... they need problems that are open-ended ...

what you need is problems that kids have to think of various ways to solve them."

Teacher D: "I haven't with this group yet. When we come to problem solving I will probably give them a strategy in the form of steps to take, approaches to a problem, and key words, clue words, and that sort of thing."

Question 7(b) Do you think that students need to be taught strategies for problem solving and if so, why?

Responses:

Teacher A: "I would think so in certain cases .... but you don't have enough time."

Teacher B: "Yes, definitely. It's something common that they need not only in math - in just everyday living ..."

Teacher C: "Definitely. That's the most important part of math."

Teacher D: "Yes .... it would give them some routine way of approaching a problem, a way of breaking a problem from a mass of sentences ... into something that they can translate into a mathematical form, be able to extract from the problem, important parts."

Summary and Discussion

Generally, these teachers made a reasoned choice of the manner in which they would introduce the concept being taught. Three of the teachers indicated that they considered pupil knowledge of mathematical terminology important. Although only two teachers were asked question 1(c), overt teaching behaviors and SRI protocols indicated that all four teachers were cognizant of specific student weaknesses in math understanding and took measures to overcome them. Their choice and sequence of example problems were deliberate and provided a strong basis for pupil understanding. Consistent attention to format through the lessons was singularly lacking. Not one teacher mentioned in the SRI protocols, the importance of format and/or notation in the teaching of mathematics. Yet all four teachers indicated an awareness of pupil misunderstandings due to format. Bases for teacher choice of student to answer questions are presented on page . All four teachers were conscious of their intent to give all students in the class a fair proportion of questions to answer, although a number of other factors such as pupil inattention, pupil understanding, and pupil ability to answer correctly often determined that choice. The bases for asking the same question of two or more students when no answer was given by the former student, varied. However, the pace of the lesson, time constraints, teacher perception of pupil affective states and a desire to maintain the instructional flow were factors which guided teacher decisions to pursue a question with one student or to ask another student. Three reasons mentioned for pursuing a question with a single student were

1. to provide a review for all the students,
2. that it wouldn't take too long, and

3. that the teacher didn't want to leave the student with a bad feeling.

Three teachers indicated an awareness of differential pupil ability to verbalize mathematical thinking. An instance arose in a pupil SRI during the pilot study where a pupil in grade five was unable to verbalize his understanding of a concept. Not only did he lack an adequate math vocabulary to do so but he also displayed an incomplete understanding of the concept taught during the lesson.

While the four teachers revealed that they had used and do use different approaches to teach the same mathematical concept, there seemed to be implicit evidence from their responses that perhaps they do not habitually analyze their teaching methods as inductive or deductive. Certainly both methods lend themselves to heuristic teaching if that is the intent of the teacher. However inductive methods and heuristically used deductive methods require considerably more planning of content sequence and components, an approach that if used frequently can become a routinized procedure and one that induces pupil thinking modes requiring higher levels of information processing. If teachers tend to use the approaches presented in teacher math manuals or guides, these may need to be examined for appropriate proportions of inductive and deductive methods as well as for the incorporation of heuristic teaching strategies. Students who have difficulties with inductive reasoning may need more practice and/or appropriate problems for which they possess the prerequisite knowledge.

'Problem solving' is often associated exclusively with 'word' problems in mathematics even though a problem implies a difficult question to be answered or a perplexing situation that requires a solution. The teachers in this study interpreted question 7(a) as referring to math 'word' problems. Perhaps this fact is more significant than their responses to the question. Strategies for attacking math problems or answering math questions which are numerically stated can also be taught. Strategies for writing math tests and exams can be taught as well. Such strategies save teaching time and constitute facets of heuristic teaching. If teachers and teacher math manuals segregate 'word' problems as a separate unit of study, it belies the functionality of mathematics.

All four teachers were of the opinion that students need to be taught strategies for problem solving. One teacher viewed this as the most important part of mathematics.

Coping with Heterogeneous Mathematics Classes

Although the topic was not a focus of the study, it arose in the SRI protocols as non-interactive data proffered by the teachers. Pupils in three of the four classes videotaped possessed a wide range of mathematical abilities while the fourth class was above average as a group. Each teacher expressed an opinion regarding ability grouping for math instruction and elaborated on how they coped with heterogeneous classes in math.

(I stands for interviewer and T for teacher)

Teacher A

I: Do you remember what you were thinking when ___ came up?

T: Like I was thinking .... He's my greatest kid in the room. Well him and _____. ... I've got some academically advantaged kids mind you, above average kids. But those two kids are verging on gifted.

I: Oh.

T: Not really, but verging.

I: Does it present any problem in the math instruction to have two kids like that or one in each grade?

T: No. Well, it doesn't present me with a problem. Although, I mean I don't mind that kind of challenge at all. I'd like to have a whole class like that ... You know, you're racing to find enough stuff for them to do providing you can train them to be independent. And most of those kids can be shown how to do that ....

I: Do you think it's a problem for them?

T: Yes, I think it's a problem for them because I know I don't really have enough time to really --- like I say to really get them into something. But then that's my opinion. I'm thinking, you know, oh your time is so important. You've got to be learning all the time. But really, you know, they know so much for their ages already. Maybe it isn't necessary but I always feel, you know, I'm wasting their time by not giving them something. Or they could be so much better. Just think what they could do if only I had time. So they maybe don't think it's a problem but I know they're kind of being held back.

I: Have you ever considered ability grouping for math instruction?

T: Oh yeah, I'd really like to but well, I've got two groups already (split class). I would just love to be able to split up my 4's but I just know I won't be able to handle it. They would get even less out of it then. As it is, well, like I'm trying to individualize by having them go ahead at their own rate in their regular text. So I'm hoping to overcome a bit of the drawbacks from not grouping them.

Teacher B

T: .... at times I would use him but I got to a point I said I'm not going to ask _____ anymore because he knows all the answers so I went to somebody else .... I'll have to actually settle him down sometimes because he knows all the answers all the time. I avoid him at times.

T: _____ brought up an interesting point but I didn't pursue it. I could have but most of the students wouldn't understand it. I wanted to go on with the lesson.

T: The ones that can do an exercise quickly and finish off, they can go ahead and they love to work on their own. And the ones that are struggling with certain concepts, they'll just pace themselves and sometimes not even do it.

I: Have you ever considered ability grouping for math instruction?

T: .... again it would depend on what material you have .... You could probably try a group session where you see if they can evolve the concept.

Teacher C

T: I try to (check every pupil's seatwork). I also do that during my marking because then I know which kids I have to re-teach ... I don't believe in grouping kids. I feel it's a waste of time. You cut down the instruction time by a half if you've got two groups. You can only spend half as much time teaching, therefore you can spend half as much time remediating. So I would rather do all my remediation by picking out the weak student during the lesson and re-teaching them if necessary.

I: .... do you do anything in groups with the more able students?

T: .... I always teach the total program. And I have fairly challenging work for them all. I would rather cut down the work that the lower kids are doing. And so in terms of extra things that the smarter ones are doing, I gear myself to the smarter ones and the lower ones keep up. Oh, I shouldn't say that I gear it to the upper because I think that probably, you know, in all honesty, the upper kids could move a heck of a lot faster. But then, what's the point? So I believe that if you make it fun for the kids and you make it understandable for the kids, then the smarter ones haven't suffered. Because, you could outstep these really, really smart kids. .... They should probably be stretched more than they are. But then, at the same time, you need good materials if you're going to give that kind of individual assignment. And I really don't think that there is too much available for us that kids can work that independently. Even the bright kids need instruction. And as far as I'm concerned, I suppose I'm dealing more with the basic skills. But I would sooner they learn something the right way the first time rather than learn it wrong and then have to re-teach them.

I: Have you ever considered ability grouping for math instruction?

T: Ah, grouping according to ability is good ... I find that all the kids can be successful in math. And if you have the low kids together you can travel at a good pace for them to learn. However, as soon as you have that same group in Language Arts, they seem to miss out on models of good answers which they really, really need. It's not so important in math .... about 7 years ago I think, I used to have groups in math and somewhere along the line I decided that that wasn't necessary at all.

Teacher D

T: ... I would know that some of them would be finding it monotonous because of the range of abilities. There's everything from a ___ to a ___ in the class --- everything from complete attention and perfect marks to the opposite extreme --- distraction and low ability.

I: Does that present problems for your instruction?

T: It does usually provide some problems in instruction because you have to move along at a rate that is going to hit most of the kids knowing full well that some of them aren't getting it, some of them have already got it.

I: Have you ever considered ability grouping for math instruction?

T: The ability grouping concept, I guess, would be quite fine. I would prefer to take the approach of getting most of the children and then providing an enrichment sort of atmosphere for the ones that are very bright and either by having some of the bright ones when they're done, help those who are having some difficulty in their work or by being able myself to give personal attention to the ones that are having difficulty. I'd rather take that approach. It leaves my time a little more flexible. I don't have to hop from one group to another.

I: Have you tried ability grouping in math or any other subject?

T: Yes. I find it a very good approach in language arts. I've found it less than satisfactory in math .... Because when a child is having some trouble in math, he needs or wants attention to the problem immediately. And if I'm with another group, I'm not able to either give him personal attention with the problem or provide him with someone else who can do it.

Summary

All four teachers indicated an aversion to ability grouping in math instruction. Two constraints mentioned were the organizational problems of grouping and the lack of suitable materials for independent work. Two teachers also revealed that they thought more could be done in math instruction to challenge the brighter students but did not offer any suggestion for accomplishing this.

Validation

An important problem encountered in using stimulated recall techniques is the validation of that recall. Whether a teacher is reconstructing or reproducing thoughts and feelings experienced during instruction is difficult to determine. An additional factor influencing that recall is the difference in observational perspective. During the viewing of the videotape the teacher observes him (her)self and the students, while during instruction that view excludes the teacher as a participant in classroom events. The effect of this difference on teacher recall is even more difficult to assess. Cross checks of the SRI protocols for internal consistency of teacher recall were made. Only one instance of conflicting teacher statements occurred in the eight teacher SRI protocols. This incident was related to pupil miscuing. In SRI D-1 the teacher comment was as follows:

T: .... Yeah, that was sort of a surprise to me... I don't think I've ever had the experience with this class that they had not known when the teaching part of it was over or the instruction part of it was over ...

I: To what did you attribute it?

T: ... it would be due to the presence of the videotape
equipment.

Whereas in SRI D-2 when the same miscuing occurred the dialogue went as follows:

I: Now ... would this be connected with my presence and
the videotape in the room or does this occur in other
lessons as well? Other math lessons?

T: Yes, some of them seem to do that quite regularly.

Teacher responses to interviewer interjections of "Do you remember (or recall) what you were thinking then?" consisted of eight instances where the response was either, "No, I can't remember." or "I can't recall for certain." while teacher responses to interviewer questions, "Did you notice _____?" consisted of five instances where the teacher response was "No, I didn't." These responses provided inferential evidence that teachers were committed to honest recollections of their interactive thoughts. Further support of this was found in the number of instances where teachers confirmed that certain thoughts they revealed were not interactive.

A further check was made to determine the number of leading questions asked by the interviewer, a factor which might influence teacher response. Of the 855 interviewer interjections in the 8 SRI protocols less than 1.1% were classified as 'leading'. Even among these, a cross check of teacher responses to a question such as, "Did you think that it might have confused some students?" elicited mixed responses of "Yes" and "No".

That teacher view of him (her) self as a participant in classroom events revealed the training effects which this technique provides. Those views which focused upon teaching behavior were largely negative, indicating honest and total teacher disclosure which was attributable to the non-evaluative nature of the study, the professional security of these experienced teachers and the comfortable rapport which had been established between the teachers and the interviewer. In spite of the measures taken in this study to ensure valid disclosure, the validity problems inherent in this type of research are far from resolved. A possible means to obtain concurrent validity might be the simultaneously use of observational techniques and/or ethnographic studies conducted by different investigators.

Teacher Selected Nodes

Nodes at which teachers stopped the viewing of the videotaped lesson to initiate dialogue were categorized under the following foci.

Instructional Move (IM)

Pupil Response (PR)

Pupil Behavior (PB)

Unsolicitated Pupil Question (UPQ)

Unsolicitated Pupil Comment (UPC)

Choice of Student to Answer Question (COS)

Pupil Work at Desk (PW-D)

Pupil Work at Board or Overhead (PW-B)

Pupil Understanding (PU)

Non-interactive (NI) These were thoughts that occurred during the SRI but not during instruction.

Other (O)

A comparison of the nodes chosen by the teachers during the first interviews (Table 16) revealed a strong focus on instructional moves which they related to pupil understanding, pupil motivation, pupil attitudes, differential treatment of pupils, and self-evaluation. The detailed disclosure by all four teachers at these nodes indicated a high degree of self-monitoring and proactive teaching. In the second interviews, this focus was maintained by teachers A and C but not by teachers B and D. A distortion in teacher chosen nodal focus may have been caused by the higher number of interviewer chosen nodes and the interjection of the semi-structured questions. While none of the four teachers exhibited defensive reactions to the questioning technique, it may have interfered with their spontaneous (teachers B and D) recall. Teacher B disclosed the fewest thoughts although this may not have been due to lack of stimulation by the videotape for he seemed to be more distracted during the interviews than any of the other three teachers. This distraction may have been caused by several interruptions as the interviews were conducted in an office which also housed the physical education equipment. This teacher also had a number of immediate subsequent commitments.

A further analysis of category PB revealed that this behavior was lesson content related. Category COS was analyzed to determine why the teacher chose a specific pupil to answer a question. In the twelve instances cited the following reasons for such a choice were revealed.

Reason for Choice	Frequency
1. To gain or regain the pupil's attention to the lesson.	3
2. Because the pupil would know the correct answer.	5
3. The pupil had not yet had a turn to answer.	1
4. Teacher concern about the pupil's understanding of the concept.	4
	13 Total

While the dialogue in each segment of SR interviews might contain a number of foci, the categorization of node was based on the teacher initiated disclosure prior to the interjection of any probing questions by the interviewer. The pilot study revealed in one case that the teacher may have had a preconceived notion of what type of recall the researcher was interested in and consequently revealed considerable non-interactive data about pupil behavior (past and present), pupil performance (past and present) as well as curriculum requirements. Circumvention of such an occurrence in this study was accomplished through orientation procedures and a short briefing just prior to the interview.

Table 16

TEACHER SELECTED NODES

SRI	IM	PR	PB	UPQ	UPC	COS	PW-D	PW-B	PU	NI	O	TOTAL NO. OF TEACHER SELECTED NODES	NO. OF INTER-VIEWER SELECTED NODES	TOTAL NO. OF NODES
A-1	22	5	2	2	1	4	0	0	0	4	0	40	8	48
A-2	13	4	5	0	1	3	1	1	1	0	1	30	12	42
B-1	7	0	0	1	0	1	0	1	0	1	0	11	5	16
B-2	1	1	3	0	1	1	0	0	0	0	0	7	7	14
C-1	11	1	1	0	0	0	0	0	4	0	0	17	4	21
C-2	5	2	0	0	0	0	1	0	0	0	0	8	17	25
D-1	10	5	4	1	0	2	2	0	0	0	2	26	5	31
D-2	1	0	4	0	1	1	1	0	0	0	1	9	7	16

Personal and Professional Data Questionnaire

The four volunteers in the study were asked to complete a Personal and Professional Data Questionnaire (Appendix H). Ten items yielded information which provided a limited comparison of their teacher training and teaching experience. The information is provided in Table 17. Two of these teachers were male and two female. Two were between 25 and 30 years of age and two between 31 and 35 years of age. All four had at least six years of teaching experience in elementary school grades and at least four years of university education. None of the four had majored in mathematics during undergraduate or graduate training but one teacher had taken two full classes (one of Math and one of Statistics) in a university mathematics department. All four teachers had taken at least one half-course in mathematics methodology. Two of the teachers felt that mathematics was the subject area they were most adequately prepared to teach in elementary school and three of the four teachers stated that of all subject areas taught in elementary school, mathematics is the area they enjoy teaching most. Three of the four teachers had been involved in a professional activity related to mathematics programs or curricula. The fourth teacher was replaced by a substitute teacher for one half day during the two weeks this researcher spent in the school, to attend an inservice session on mathematics .

This information was collected to reveal any marked differences among the teachers which could then be related to their information processing styles, their beliefs about mathematics and mathematics instruction, and their instructional behavior.

BAMS and BAMIS

Each of the four teachers completed two instruments (BAMS - Beliefs about Mathematics Scale and BAMIS - Beliefs about Mathematics Instruction Scale) (Appendix G) which measured their beliefs about math and math instruction along a formal-informal continuum. Each instrument had twenty items of which ten were formal (negative) and ten informal (positive). The five-point Likert-type scoring provided for a neutral (undecided) category, two levels of agreement (agree (A) and strongly agree (SA)) and two levels of disagreement (disagree (D) and strongly disagree (SD)) on either side. The scores obtained by the teachers on each instrument are given below.

Teacher A		% Deviation (from 60)
BAMS	61	+ 1.7%
BAMIS	57	- 5.0%

Teacher B		% Deviation (from 60)
BAMS	72	+ 20%
BAMIS	62	+ 3.3%

Teacher C	% Deviation (from 60)	Teacher D	% Deviation (from 60)
BAMS 69	+ 15%	BAMS 70	+ 16.7%
BAMIS 70	+ 16.7%	BAMIS 57	- 5.0%

Since a score of sixty represents a neutral position with no overall dimension of either formal or informal beliefs, the scores obtained do not indicate radical beliefs on either instrument. In comparing the scores obtained on both instruments by individual teachers, all teachers had similar beliefs about mathematics and mathematics instruction. Two teachers (B and D) had the most informal beliefs about mathematics but in both cases, their beliefs about mathematics instruction were more formal. (B- 13.8% more formal than BAMS score, D- 18.6% more formal than BAMS score.)

The beliefs about mathematics and mathematics instruction of two teachers were almost congruent (A=6.7% difference and C=1.7% difference with reference to BAMS score), while the other two teachers (B and D) tended to have more formal beliefs about mathematics instruction than mathematics. This incongruency was somewhat evidenced in their instructional behavior observed over two weeks time by this researcher. Neither of these latter two teachers made any written or verbal comments about the items on either instrument. In the case of Teachers A and C, the following comments were written on BAMS.

Teacher C - #6 - once you have some basic skills or
tools to work with.

#9 - more logic develops.

#16 - Yes, because what we do in math we do by definition.

#17 - number crunching - yes, setting up - no.

and on BAMIS

Teacher C-#13 - but not in a class of thirty.

#16 - small assignments.

#18 - should not be only method used.

#20 - depends how guided and how much discovery is required.

Teacher A-# 3 - only as a prelude to learning standardized symbols.

4 - not for poor students.

5 - not in elementary grades - only very bright.

# 8 - this saves time especially for poorer students.

#14 - not practical for elementary in math, but in other areas, yes.

#15 - this is excellent for very bright only.

#16 - but not so much in math.

#17 - but it does simplify things for the teacher.

Teacher A also made the following comments.

"I really believe that the discovery methods or guided discovery methods work very poorly with weaker students, okay to poorly with average students and very well with bright or creative students. Teachers tend to use methods that give them the best 'obvious' results. In math this means 'correct', 'exact' answers. Ingenuity, creativity, and original methods are often difficult to assess, take much individual pupil/teacher time, and require more effort in general. If you used such methods generally with the entire class I doubt you would have 'good' measurable results. (Unless you have ten aides and a computer).

If I had a class of ten very bright kids however, I would probably use 'discovery' exclusively. I think it would promote many aspects of a well developed mind and would be far more valuable than memorized methods, which are probably restrictive even in math."

While all four teachers differed to some extent in their two scores, the widest discrepancy occured in D's score which indicated that s(he) was considerably less informal in his (her) views about mathematics instruction than mathematics. ((% Deviation from neutral position = 16.7%) - (%Deviation from neutral position = -5.0%) = 31.7%)).

Ambivalence scores were also computed on each of the scores of the four teachers. This score indicates the degree to which responses to positive and negative items on each instrument were consistent.

Ambivalence Quotient (A.Q.)

Teacher	A	B	C	D
BAMS	12.8	7.14	3.2	6.66
BAMIS	16.3	15.8	20.0	2.32

It indicates that the higher the AQ score, the greater the inconsistency in response. That is, if one individual expresses agreement with both positive and negative items, either his attitude or belief is inconsistent or his interpretation of the items differs from the interpretation of the item judges. The above scores are considerably lower than those found in Collier's study. The highest mean AQ for BAMS at any stage of preparation or at either achievement level was 33.0 and the lowest 16.8, while on the BAMIS they were 31.2 and 15.2 respectively. A low AQ score would reflect a higher degree of consistency of beliefs more likely to be found in mature teachers with several years of teaching experience. In three of the four highest AQ scores obtained in this study, (A - BAMS, A - BAMIS, C - BAMIS) bases for inconsistency were evidenced in the specificity and qualifications added by teachers A and C in their interpretations of the items.

Of special note, are the scores of teachers C and D. In the former (C), the BAMIS AQ of 20 was the highest in the study, yet this teacher used more heuristic instructional strategies than any of the other three teachers. Teacher D had the lowest AQ on BAMIS which also appeared to be congruent with his instructional strategies.

Table 17

Personal and Professional Data Questionnaire

Teacher	A	B	C	D
Age	25-30	25-30	31-35	31-35
No. of years teaching experience	6	7	10	10
Grades taught in last five years	1,2,3,4,5, 6.	Mostly 6, one 5-6, some 1-4, P.E., Science	3,4,5.	4,5,6.
Degrees held and year obtained	B.Ed.-1972	B.P.E.-1970, B.Ed.-1975, PD/AD-1971, Grad. Dip. Ed.-1977	B.Ed.-1966	B.A.-1966 M.B.A.-1977
Area(s) of (in Training) Specialization	Phy. Ed.	Phy. Ed. Reading Ukrainian Elem. Ed.	Major-Social Studies Minor-Special Ed.	English Geography Organizational Theory
Field of Specialization (Subject area you consider most adequately prepared to teach)	Music	Phy. Ed.	Math	Math
EDCI course(s) taken in Math Methodology	1/2 class	1/2 class	1 full class	1/2 class
Math Course(s) taken in Faculty of Science (Academic Math)	------	-------	-------	Math 201 (Full) Math 255 (Full)
Subject area in Elementary School you enjoy teaching most	Math	Lang. Arts	Math	Math
Recent Activities related to Math Teaching	School Rep. re: EPSB Math Program	School Rep. on Math Committee re: Curriculum	-------	Field Tested (Gr. 6) pilot projection in Geometry

SECTION B

Stimulated Recall Data (Pupils)

Introduction

The study of pupil information processing during instruction is a necessary counterpart to the examination of teacher information processing during instruction. By capturing simultaneous teacher and pupil thoughts during instruction, the immediate reciprocal influences of teacher and pupil behavior can be examined. In particular, an analysis of pupil recall of interactive thoughts reveals the foci of a pupil's attention or his (her) monitoring behaviors and an idiosyncratic interpretation of instruction and classroom events. A content analysis system (CAPIT, Appendix F) was developed to analyze pupil interactive thoughts revealed in the stimulated recall interviews.

Following a brief description of the CAPIT categories, the findings from the micro-analysis of the pupil stimulated recall data are presented. Three categories (MS, MT, and MP) were sub-categorized to examine the substantive components of the thought units in each category. The results of the macro-analysis are presented as student profiles.

Interactive Thoughts - Micro-Analysis

Twenty SRI's were conducted with twelve pupils from grade four, five, and six. Six of the pupils were girls and six were boys. All but four of these pupils were interviewed twice. The SRI's were audiotaped, transcribed and analyzed. CAPIT provides for the categorization of pupil interactive thoughts into eleven discrete categories.

1. Mathemagenic Orientation (MO): Pupil perceptions of stimuli relevant to the mathematical content of the lesson.
2. Mathemagenic Encoding (1) (ME-1): Pupil thoughts which are focused on encoding mathematical stimuli.
3. Mathemagenic Encoding (2) (ME-2): Pupil thoughts which reveal that mathematical stimuli have been encoded or translated into a personally meaningful form.
4. Monitoring-Self (M S): Pupil thoughts which reveal that the pupil is aware of and monitoring his own actions and thoughts. These thoughts contain _no_ reference to the mathematical content of the lesson.
5. Monitoring-teacher (MT): Pupil thoughts about the teacher which include interpretations of or reflections upon teaching behavior. These thoughts contain _no_ reference to the mathematical content of the lesson.

6. Monitoring-Peers (MP): Pupil thoughts about other pupils in the class. These thoughts contain no reference to the mathematical content of the lesson.
7. Feelings (F): Pupil emotions or affective states experienced during the lesson.
8. Information-Relevant (IR): Pupil thoughts which reveal information possessed prior to the lesson but relevant to the lesson.
9. Information-Irrelevant (II): Pupil thoughts which reveal information possessed prior to the lesson but irrelevant to the lesson.
10. Ecological (EC): Pupil thoughts about the classroom environment, intangible classroom events, or thoughts about the videotaping of the lesson.
11. Extraneous (EX): Pupil thoughts which are not related to the lesson events or lesson content.

Table 18 presents the percentage distribution of frequencies of thought units in each of the eleven categories. Average percentage distributions were calculated and used for comparative purposes. Pupil interactive thoughts revealed in the 20 SRI's were focused on themselves primarily (AV.% = 22.4). Next in frequency were thoughts in which they had encoded mathematical stimuli into meaningful forms (ME-2, AV.%= 13.1) and thoughts indicating perceptions or awareness of mathematical stimuli (MO, AV. % = 13.3).

Approximately one-third of their thoughts were focused on mathematical stimuli and the encoding of mathematical stimuli (MO=13.3, ME-1=7.1%, ME-2=13.1%). Next in frequency were thoughts about their peers (Av.%=11.8), their teachers (Av.%-10.3) and thoughts revealing information relevant to the lesson (Av.%=11.3). Few recalled thoughts were about feelings (Av.%=4.8) experienced during the lesson although some of these feelings may have been pervasive. Few thoughts about the classroom environment were disclosed (Av.%=4.3) although one student (DD-1-1) expressed an inordinate interest in the camera as he had done during the familiarization phase. Minimal extraneous thoughts (Av.%= 1.0) or thoughts revealing irrelevant information (Av.%=1.1) were recalled. Although no 'consistent' patterns in frequency distributions of interactive thought units were discernable among students in the same lesson, there were a number of similarities between the interactive thought unit frequencies of the same student in the two lessons videotaped.

To preserve anonymity the students interviewed were coded as follows: For student AA-1-2, AA indicates that the student was a member of the class taught by teacher A, 1 indicates the first lesson that was videotaped, and 2 represents the second student interviewed. Similarly, CC-2-4 represents the fourth student interviewed after the second videotaped lesson taught by teacher C. The following 8 students were interviewed twice.

GR. 5	AA-1-2	GR. 4	CC-1-2	GR. 5	DD-1-1
	AA-2-2		CC-2-2		DD-2-1
GR. 6	BB-1-1	GR. 4	CC-1-3	GR. 5	DD-1-2
	BB-2-1		CC-2-3		DD-2-2
GR.6	BB-1-2	GR.4	CC-1-4		
	BB-2-2		CC-2-4		

Mathemagenic Orientation and Mathemagenic Encoding

Although the average frequency of thought units recalled in the three categories MO, ME-1, and ME-2 comprised approximately one-third of all thought units, the individual pupil frequencies ranged from 14.2% (DD-1-1) to 51.2% (DD-1-2) in these three categories. Two students' recall in these three categories constituted more than 45% of all interactive thoughts recalled in each of the two SRI's conducted.

CC-1-4 = 46.3% (Grade 4)   DD-1-2 = 51.2% (Grade 5)
CC-2-4 = 51.1% (Grade 4)   DD-2-2 = 47.3% (Grade 5)

These two students exhibited 'on task' behaviors during the lessons yet in three out of four SRI's the degree of teacher monitoring (MT) was lower than the average frequency of MT thoughts. That is, unless the teacher be-

Table 18

Percentage Distributions of Pupil Interactive Thoughts Over CAPIT Categories for each lesson

Student	Thought Category												
	MO	ME-I	ME-II	MS	MT	MP	F	IR	II	EC	EX	MO+ME-I,II	N[a]
	%	%	%	%	%	%	%	%	%	%	%	%	
AA-1-1	17.1	3.95	19.74	18.4	3.9	9.2	3.9	6.6	6.6	3.9	6.6	40.79	76
AA-1-2	15.0	1.00	8.00	37.0	19.0	5.0	9.0	5.0	0.0	1.0	0.0	24.00	100
AA-2-1	27.3	0.00	22.70	9.1	27.3	4.55	0.0	4.55	0.0	4.55	0.0	50.00	22
AA-2-2	9.8	0.00	12.2	21.1	8.9	17.9	8.9	15.4	0.0	5.7	0.0	22.00	123
AA-2-3	10.3	1.47	7.35	22.1	10.3	11.8	13.2	22.05	0.0	1.47	0.0	19.12	68
BB-1-1	5.6	2.5	6.6	36.4	14.6	3.0	8.6	20.2	1.0	1.5	0.0	14.7	198
BB-1-2	10.5	3.5	9.6	28.1	9.6	14.0	6.1	13.2	1.8	2.6	0.9	23.6	114
BB-2-1	12.0	3.0	8.4	39.8	6.0	4.8	3.6	21.7	0.0	0.6	0.0	23.4	166
BB-2-2	17.4	4.3	12.2	31.3	6.1	10.4	2.6	13.0	0.0	0.9	1.7	33.9	115
CC-1-1	5.8	13.5	9.6	26.9	7.7	9.6	3.8	15.4	0.0	3.8	3.8	28.9	52
CC-1-2	4.8	4.8	25.8	12.9	8.1	21.0	6.5	9.7	3.2	0.0	3.2	35.4	62
CC-1-3	25.0	5.0	9.0	29.0	10.0	13.0	3.0	6.0	0.0	0.0	0.0	39.0	100
CC-1-4	8.4	17.1	20.7	17.1	2.4	15.9	9.8	6.1	0.0	2.4	0.0	46.3	82
CC-2-2	16.5	14.1	16.5	16.5	10.6	12.9	2.35	2.35	5.9	0.0	2.35	47.1	85
CC-2-3	14.8	6.5	12.0	22.2	12.5	16.2	2.8	10.2	1.9	0.0	0.9	33.3	216
CC-2-4	16.3	17.4	17.4	11.6	15.1	14.0	1.2	7.0	0.0	0.0	0.0	51.1	86
DD-1-1	4.5	6.5	3.2	15.5	11.0	16.1	1.9	18.7	0.6	21.9	0.0	14.2	155
DD-1-2	15.6	17.8	17.8	11.1	4.4	20.0	6.7	4.4	0.0	2.2	0.0	51.2	45
DD-2-1	10.4	5.2	9.8	17.3	10.4	10.4	1.2	13.3	0.0	21.4	0.6	25.4	173
DD-2-2	19.3	14.0	14.0	24.6	8.8	5.3	1.8	10.5	0.0	1.8	0.0	47.3	57
Average	13.3	7.1	13.1	22.4	10.3	11.8	4.8	11.3	1.1	4.3	1.0		
%													

[a] Number represents the total number of interactive thoughts reported in each stimulated recall interview,

haviors were lesson content oriented, they seemingly did not find it necessary to monitor his (her) every action. Another student (AA-2-1) who was interviewed once also revealed a high frequency (51.2%) of thought units in these three categories. This student proved to be the only exception among the twelve students interviewed. That is, the SRI was unsuccessful in the sense that the student did not freely disclose his (her) interactive thoughts. Although the familiarization phase revealed that this student was very quiet, a comfortable rapport had been established. The high interviewer/interviewee 'initiation of dialogue' ratio (11:0) indicates the difficulty encountered by this investigator during the interview. During the lesson videotaped, this student (AA-2-1) raised his (her) hand in response to every question asked by the teacher, was asked to respond to one question and did so correctly. This same student also revealed the highest frequency (27.3%) of MT thoughts although only 22 thoughts were recalled in total. When asked, whether s(he) had noticed how frequently this student raised a hand to answer a question, the teacher remarked,

> "Not in particular .... no doubt s(he) knows all the answers ... She's quite a good student ... The ones I'm pretty sure know, I often ignore them thinking, oh, I don't have to worry about you. Let's get to somebody on the border line and then by their responses figure out what they don't know, which is kind of unfortunate."

Student AA-1-2 whom the teacher considered to be very bright, disclosed frequencies of 24% and 22% of all thought units in these three categories. Yet he prided himself on being the only one in the class who knew how to do work sheets. The students frequently came to him (her) for help while the teacher was working with the other grade. A factor which may have influenced the distribution of his (her) interactive thoughts was the proximity of a peer. This friend moved from the back of the room to sit beside this student during the lesson presentations.

The three categories (MO, ME-1, and ME-2) include thoughts which focused explicitly on specific mathematical stimuli or encoding of mathematical stimuli; however, many thought units recalled by pupils and categorized as MS, MT, or MP were also relevant to the mathematical content of the lesson.

Monitoring Self (MS)

The thought units classified as MS contained no explicit reference to the mathematical content of the lesson. They were further analyzed according to five sub-categories as follows:

1. Expectations: These thoughts include pupil anticipations of or expectations about future lesson events, his (her) academic and non-academic performance, or lesson content.

Examples:

a. I thought it was going to be later this morning.

b. Then I'd have somebody to discuss it with.

c. I thought the sheets would be hard again.

d. I would get it wrong maybe.

e. ... would I be embarassed or not.

f. (If s(he) asked me) I could still come up with the answer.

g. I might have to switch to a new book.

2. Overt Behavior: While these thoughts refer to overt pupil behaviors they imply pre-emptory thoughts to deliberate pupil actions.

Examples:

a. I'm trying to make him (her) hear me.

b. I asked him (her) for the page number.

c. I put up my hand again.

d. I'm trying to get the teacher to look at me.

3. Reflections: Thoughts in which the pupil was reflecting on prior lesson events relevant to himself (herself) were classified in this sub-category.

Examples:

a. So it took me quite a while.

b. It seems like it's almost never me.

c. I was the only person that knew how to do it.

d. I couldn't get it.

e. Now I know I was doing it right from the first.

4. Desires: These thoughts included pupil hopes or desires relevant to future lesson events or post-lesson events.

   Examples:

   a. I didn't really want to explain that answer.
   b. I wanted to finish (the fractions) and then tell everybody.
   c. I was wishing we could get on to something more interesting.
   d. ... so I wouldn't have any homework.

5. Introspections: While the SR technique required introspection in retrospect, pupils also revealed that they monitored their own thoughts during the lesson. Such thoughts were sub-categorized as introspections.

   Examples:

   a. I didn't really keep it in my mind.
   b. I sort of dozed off.
   c. I sort of got distracted from the work.
   d. So I was thinking unpleasant thoughts about _____.
   e. I didn't understand that.
   f. I wasn't interested in all that talk about ----.
   g. Well, I knew I must have been learning.

In all five sub-categories, the focus of the thoughts is on the pupil himself (herself). It indicates a self monitoring function in which the pupil is aware of his (her) desires, expectations, behaviors, thoughts, and is reflecting on prior events and their implications. Table 19 presents the percentage of all MS thought units in each of the five sub-categories for each lesson. The average frequencies in descending order were as follows:

Overt Behaviors = 37.2%
Introspections = 23.1%
Reflections = 18.4%
Expectations = 10.9%
Desires = 10.5%

As a frame of reference for determining patterns of consistency among the recalled thought units of the same pupil in two SRI's, an arbitrarily devised 'consistency' index was calculated as follows:

$$\text{C.I.} = \frac{|F_1 - F_2|}{F_1 + F_2}$$

where F_1 represents the percentage frequency of thought units in a specific category or sub-category revealed in the first SRI and F_2 the percentage frequency of thought units in the same category or sub-category revealed by the same pupil in the second SRI. Perfect consistency is indicated by a C.I. of 0.0 and total absence of consistency by 1.0. Only those frequencies with a C.I. of less than 0.20 will be referred to as 'consistent'.

While only two pupils (BB-1-1 and DD-1-2) exhibited 'consistent' patterns of high frequency in the "introspection" sub-category, the former disclosed 45 such thoughts in the two SRI's and the latter 7. Pupil BB-1-1 disclosed 135 MS thought units in the two SRI's and pupil DD-1-2, 19. In fact pupil BB-1-1 revealed the highest 'consistent' frequency pattern of self-monitoring (MS) thought units of the eight pupils who were interviewed twice.

Monitoring Teacher

Thoughts in which pupils monitored teacher behavior without explicit reference to the mathematical content of the lesson were classified as MT. These thoughts were further analyzed under four sub-categories.

1. Perceptions: Pupil thoughts which revealed an awareness of teacher overt behaviors.

   Examples:

   a. He (She) was just walking by.
   b. He (She) said, "Put it in the cloakroom."
   c. He (She) just walked away.
   d. He (She) picked someone else.

2. Reflections: Thoughts in which the pupil reflects upon prior teacher behavior observed during the lesson.

   Examples:

   a. He (She) made a mistake him (her)self.
   b. Why is that teacher reviewing us again?

c. The teacher won a point.

d. He (She) didn't ask _____ or me.

3. Interpretations: Thoughts which reveal an attempt by the pupil to probe the teacher's mind. Frequently they represent pupil hypotheses concerning teacher intent and bases for teacher behaviors.

Examples:

a. He (She) wants somebody else to answer.

b. I think that he (she) thinks that I got the question.

c. He (She) didn't ask me because I knew it.

d. I think that's why he (she) didn't hand them out.

e. He (She) must have thought I was scratching my head.

f. I think he (she) wanted to get everybody awake again, especially _____.

4. Expectations: Thoughts in which the pupil anticipated future teacher actions in the lesson.

Examples:

a. I thought he (she) was going to go by rows.

b. I thought he (she) would get mad.

c. ... so he'd (she'd) never ask me.

d. ... he's (she'd) probably just come in and start explaining on the board.

e. ... then the teacher would consider it right.

Table 20 presents the frequency distribution over the four sub-categories for each lesson. The average percentage frequencies in descending order were as follows:

Interpretations = 44.4%
Perceptions = 35.8%
Reflections = 15.6%
Expectations = 4.1%

The high average frequency of pupil interpretations of teacher behavior constitutes one basis upon which the reality of classroom life is idiosyncratically constructed by pupils. Since the average frequency of MT thoughts recalled was 10.3% of all interactive thoughts recalled, an average of 4.57% of all interactive thoughts were focused on _interpreting_ teacher behaviors. One student, CC-1-2 exhibited a 'consistent' percentage frequency of both MT thought units and MT interpretations in both SRI's, although these MT thought units represented approximately 9.4% of all this pupil's interactive thoughts in both SRI's.

Monitoring Peers (MP)

Thoughts in this category were also sub-categorized as perceptions, reflections, interpretations and expectations as were MT thought units. The only difference is that now the focus of each thought is on one or more peers in the class but no explicit reference was made to the mathematic content of the lesson. Table 21 presents the frequency distribution over the four sub-categories for each lesson. The average percentage frequencies in descending order were:

Perceptions =43.7%
Reflections =25.7%
Interpretations =24.6%
Expectations = 5.9%

Pupils tended to monitor the overt behavior of their peers more than they interpreted or reflected upon prior peer behaviors during the lesson. Three students (BB-1-2, CC-1-3, and CC-1-4) exhibited 'consistent' high frequencies of thought units in the category MP. Two of these students focused primarily on lesson content related peer behaviors.

Feelings

Thoughts which revealed pupil emotions or affective states experienced during the lesson constituted on the average, 4.8% of all recalled interactive thoughts. The percentage frequency of such thoughts ranged from 0.0% to 13.2% of all interactive thoughts. The only 'consistent' high frequency of feelings experienced by the same student in both videotaped lessons was disclosed by pupil AA-1-2. This student disclosed 20 such thought units of which 11 were related to teacher behaviors. During the first SRI he overtly exhibited his emotional state while recalling an incident during the lesson in which the teacher had come to his (her) desk in response to his (her) request and had then walked away without talking to him (her). This same student was considered

Table 19

Sub-Categorization of Monitoring-Self Category

Student	N[a]	Expectations %	Overt Actions %	Reflections %	Introspections %	Desires %	Total %
AA-1-1	13	7.7	30.8	38.5	23.1	0.0	100.1
AA-1-2	37	8.1	35.1	27.0	18.9	10.8	99.9
AA-2-1	2	0.0	100.0	0.0	0.0	0.0	100.0
AA-2-2	26	30.8	46.2	0.0	7.7	15.4	100.1
AA-2-3	15	20.0	40.0	13.3	26.7	0.0	100.0
BB-1-1	72	5.6	45.8	5.6	29.2	13.9	100.1
BB-1-2	32	18.8	31.3	6.3	3.1	40.6	100.1
BB-2-1	63	4.8	49.2	7.9	38.1	0.0	100.0
BB-2-2	36	2.8	13.9	38.9	22.2	22.2	100.0
CC-1-1	14	42.9	21.4	14.3	7.1	14.3	100.0
CC-1-2	8	0.0	37.5	25.0	12.5	25.0	100.0
CC-1-3	29	17.2	34.5	27.6	20.7	0.0	100.0
CC-1-4	14	14.3	21.4	28.6	28.6	7.1	100.0
CC-2-2	14	14.3	50.0	28.6	7.1	0.0	100.0
CC-2-3	48	8.3	35.4	47.9	4.2	4.2	100.0
CC-2-4	10	0.0	60.0	30.0	10.0	0.0	100.0
DD-1-1	30	13.3	33.3	16.7	23.3	13.3	99.9
DD-1-2	14	7.1	42.9	7.1	35.7	7.1	99.9
DD-2-1	24	8.3	20.8	25.0	29.2	16.7	100.0
DD-2-2	5	0.0	40.0	20.0	40.0	0.0	100.0
Average %		10.9	37.2	18.4	23.1	10.5	

[a] Number of thought units in the category MS.

Table 20

Sub-Categorization of Monitoring-Teacher Category

Student	N[a]	Perceptions %	Reflections %	Interpretations %	Expectations %	Total %
AA-1-1	3	66.7	0.0	33.3	0.0	100.0
AA-1-2	11	36.4	18.2	36.4	9.1	100.1
AA-2-1	6	50.0	0.0	50.0	0.0	100.0
AA-2-2	19	31.6	21.1	47.4	0.0	100.1
AA-2-3	7	42.9	14.3	42.9	0.0	100.1
BB-1-1	29	44.8	27.6	27.6	0.0	100.0
BB-1-2	11	45.5	9.1	45.5	0.0	100.1
BB-2-1	10	40.0	30.0	30.0	0.0	100.0
BB-2-2	7	57.1	0.0	42.9	0.0	100.0
CC-1-1	4	75.0	0.0	0.0	25.0	100.0
CC-1-2	5	0.0	20.0	80.0	0.0	100.0
CC-1-3	10	60.0	20.0	10.0	10.0	100.0
CC-1-4	2	0.0	0.0	100.0	0.0	100.0
CC-2-2	9	22.2	11.1	66.7	0.0	100.0
CC-2-3	27	29.6	25.9	40.7	3.7	99.9
CC-2-4	13	7.7	23.1	69.2	0.0	100.0
DD-1-1	17	23.5	11.8	35.3	29.4	100.0
DD-1-2	2	50.0	50.0	0.0	0.0	100.0
DD-2-1	18	33.3	11.1	50.0	5.6	100.0
DD-2-2	5	0.0	20.0	80.0	0.0	100.0
Average %		35.8	15.6	44.4	4.1	

[a] Number of thought units in the category MT.

Table 21
Sub-Categorization of Monitoring-Peer Category

Student	N[a]	Perceptions %	Reflections %	Interpretations %	Expectations %	Total %
AA-1-1	7	100.0	0.0	0.0	0.0	100.0
AA-1-2	5	40.0	40.0	20.0	0.0	100.0
AA-2-1	1	0.0	0.0	100.0	0.0	100.0
AA-2-2	22	40.9	22.7	18.2	18.2	100.0
AA-2-3	8	62.5	25.0	12.5	0.0	100.0
BB-1-1	6	83.3	16.7	0.0	0.0	100.0
BB-1-2	16	31.3	31.3	31.3	6.2	100.1
BB-2-1	8	100.0	0.0	0.0	0.0	100.0
BB-2-2	12	33.3	41.7	16.7	8.3	100.0
CC-1-1	5	0.0	60.0	0.0	40.0	100.0
CC-1-2	13	30.8	38.5	30.8	0.0	100.1
CC-1-3	13	53.8	38.5	0.0	7.7	100.0
CC-1-4	13	15.4	38.5	38.5	7.7	100.1
CC-2-2	11	18.2	36.4	36.4	9.1	100.1
CC-2-3	35	34.3	17.1	40.0	8.6	100.0
CC-2-4	12	50.0	8.3	41.7	0.0	100.0
DD-1-1	25	36.0	44.0	12.0	8.0	100.0
DD-1-2	9	44.4	11.1	44.4	0.0	99.9
DD-2-1	18	33.3	44.4	16.7	5.6	100.0
DD-2-2	3	66.7	0.0	33.3	0.0	100.0
Average %		43.7	25.7	24.6	5.9	

[a] Number of thought units in the category MP.

by the teacher to be extremely bright.

These thought units were categorized as follows and average percentage frequency distributions were calculated for all students.

	Feelings	%
1.	glad, happy.	27
2.	complacent.	7
3.	mad.	8
4.	confused, worried anxious, depressed.	12
5.	bored.	18
6.	disappointed.	10
7.	relieved.	5
8.	embarassed, bashful.	7
9.	tired, ill.	2
10.	surprised.	4
	Total=	100

These thought units are examined for each student in the section "Student Profiles".

Macro-analysis

A macro-analysis of the pupil SRI data was conducted to sift the data for evidence of specific phenomena such as pupil self-concept, perceived locus of control, math ematical confidence, reflective ability, introspective ability, and mathematical verbalization. This analysis was based on both interactive and non-interactive thought units. The following phenomena were revealed in the data although no generalizations were drawn on an individual pupil basis as the study was designed to explore the potential of this technique as a research tool.

1. Self-concept and Mathematical Confidence:
   Exerpts from the SRI protocols which yielded some insights into pupil self-concept were too limited to examine alone and instead were grouped with pupil disclosures revealing mathematical confidence or lack of the same. Interactive thought units from the CAPIT analysis categories of ME-II, MS, IR, and F as well as non-interactive data formed the bases for sifting the recall data for evidence of this construct.
2. Reflective Ability:
   Pupil reflections from the CAPIT categories of MS, MT, MP, and ME-II formed the basis for examining the recall data for evidence of this construct.
3. Introspective Ability:
   Pupil introspections during instruction which were identified in the CAPIT category of MS formed the basis for examining this construct.
4. Perceived Locus of Control:

both interactive and non-interactive data were examined for evidence of this construct. Pupil attributions of success or failure and of classroom events were classified as external (when perceived as beyond his (her) control) or internal (when perceived as within his (her) control) loci of control.

5. Mathematical Verbalization

Thought units in the CAPIT categories of MO and ME-II were sieved for evidence of student ability to verbalize his (her) mathematical thinking and/or mathematical understanding.

In order to provide a cross section of these individual phenomena for individual pupils, the results of this macro-analysis are presented as student profiles.

Student Profiles

While an analysis of the data for each phenomenon across all pupil SRI protocols provided a frequency count of evidential statements, it did not yield an integral glimpse of individual pupil information processing styles. For this reason, the results of the macro-analysis are presented as student profiles.

Student AA-1-1

(a) Self-concept and Mathematical Confidence

Seven statements made by this student in the recall data indicated personal confidence in his (her) mathematical ability. On one occasion, when the teacher asked this pupil to provide an explanation on the board, the pupil expressed a reluctance to explain the answer but rose to the occasion, provided the (correct) answer and returned to his (her) desk confident that s(he) had been successful. This student also disclosed that the assignment questions were quite easy for him (her) yet did request and get help from a peer on one of these questions.

(b) Reflective Ability

Five reflections were disclosed relative to self-monitoring thoughts (MS). Four of these were non-lesson content related. No reflections were disclosed relative to teacher or peer behavior during the lesson. These reflections represented 6.6 per cent of all this pupil's interactive thoughts.

(c) Introspective Ability

Three thought units were disclosed in the MS subcategory of 'introspection', all of which revealed this pupil's awareness of his (her) lack of understanding of the mathematical concept. Yet two of these instances referred to similar questions, the more difficult of which s(he) was able to answer and explain correctly at the board.

(d) Perceived Locus of Control

No evidence of pupil locus of control was found in the SRI data. Implicitly, this student exhibited an 'internal' locus through the absence of any negative reactions to teacher behavior and the absence of any expression of lack of control over classroom events.

(e) Mathematical Verbalization

The following statements made by this student in the ME-II category of CAPIT exemplify the highest level of sophistication in his (her) expression of mathematical thinking or understanding during the SRI.

> ".... because when you fold it again, the number doubles."
>
> ".... like all the rows have 3's in it so you count the whole row as one."

(f) Feelings

This student revealed three instances of emotion all relative to one classroom incident. When asked to provide the answer to a question at the board, s(he) initially, "felt sort of scared", "felt pretty good about it" after the teacher confirmed that the answer was correct, and expressed surprise that s(he) was able to come up with the correct answer.

The interviewee-interviewer 'initiation of dialogue' ratio was 5:10. The five nodes chosen by this student focused on lesson content (2), peers (1), and extraneous and ecological thought units (2). Of the first 5 segments, 4 nodes were chosen by the pupil and one by the interviewer. Of these four student chosen nodes, three were non-lesson content related. During the SRI, the student disclosed five 'extraneous' thought units, three 'ecological' and five 'information-irrelevant'. The extraneous thoughts concerned extra-curricular school activities, a school craft program, and a lunch date. This same student was also leaving on an extended family trip the following Monday. S(He) was the tallest student in the classroom (split grade), projected a confident demeanor, a 'matter-of-fact' attitude toward lesson activities and although s(he) was one of the students referred to by the teacher as "cooperative" and not demanding attention, s(he) was frequently relied upon to inform the teacher of the time on the clock in the adjoining classroom.

Student AA-1-2

(a) Self-concept and Mathematical Confidence

Nineteen statements in the first SRI and eight in the second SRI made by this student revealed his (her) confidence in his (her) mathematical ability. Statements such as the following indicated a high level of confidence.

> "I had my hand up on all the questions."
>
> "I was the only person who knew how to do it."
>
> "I knew I'd be able to get that sheet after I looked at it."
>
> "It's so easy."
>
> "I knew all the stuff."
>
> "When I get a question it's usually right."
>
> "I had to tell everybody how to do it."

There were four statements made by this student in the first SRI and none in the second SRI, indicating confusion relative to the mathematical content of the lesson. Two of these were related to a peer initiated question and two were related to the worksheets. The student commented on how blurry the worksheets were but noticed that his (her) copy was quite good. Many of the students came to him (her) for help with the worksheet questions in both videotaped lessons.

(b) Reflective Ability

Twenty-three reflections were disclosed in the three categories MS, MT and MP of CAPIT. These thought units constituted 9.8% of all this student's interactive thoughts.

(c) Introspective Ability

Five statements revealed student awareness and monitoring of his (her) cognitive functioning. Two of these statements were

> "... all I was hearing was what was going on in my mind..."
>
> "I really didn't keep it in my mind.

(d) Perceived Locus of Control

Although this student exhibited a high degree of mathematical confidence and implicit 'internal'locus of control over his academic success in mathematics, eight pupil statements in the two SRI's indicated an 'external' (perceived) locus of control over classroom events. S(He) disclosed negative emotions (6) relative to teacher choice of lesson content presented, the lack of questions asked of him (her) by the teacher, minimal verbal contact with the teacher, one comment regarding the noise level of the classroom and one regarding physical aggravation by a peer. Generally he (she) exhibited a strong sense of control over his (her) own actions and their consequences but a lack of control over the actions or reactions of others.

(e) Mathematical Verbalization

The following three statements made by this student exemplify the highest level of sophistication in his (her) expression of mathematical thinking in the two SRI's.

> "He was talking about moving the zero from one place to a different place and thinking that the decimal would stay the same."
>
> "You had to figure out the fractions before you could figure out the code."
>
> "She said we were going to be doing adding and subtraction of fractions."

(f) Feelings

Twenty instances of emotion experienced during the two lessons videotaped were revealed in the two SRI's (9 + 11). Of these, eleven were relative to teacher actions during the lesson. Four of these were angry feelings toward the teacher such as "it got me mad at him (her)" or "I kind of felt mad at him (her)". Two expressed boredom and one was expressed as "I didn't feel very good" when the teacher walked away without saying anything to him (her).

The interviewee-interviewer 'initiation of dialogue' ratio was 8:3 in the first SRI and 6:5 in the second. Student selected nodes in the first SRI focused on the teacher (5/8), him(her) self (2/8) and his (her) peers (1/8). In the second SRI, the pupil selected nodes focused on the teacher (3/6) and his (her) peers (3/6). This student exhibited in the SRI's, one of the highest percentage frequencies (37.0%) of MS interactive thoughts. The percentage frequency distributions differed considerably from the first SRI to the second SRI in six of the CAPIT categories. This inconsistency could have been due to the arrangement between the student and a peer who moved to sit beside him (her) during the lesson presentation to have this student evaluate the peer's answers prepared for teacher questions. None of the teacher questions was directed to either of these pupils during the second lesson videotaped. This student exhibited through his (her) recall of interactive thoughts the phenomenon of independent thinking on a level which placed his (her) judgements of mathematical content on a par with the teacher's judgement or perhaps even on a higher level of authority. This phenomenon was exhibited by two other students (CC-1-4 and BB-1-1).

This student (AA-1-2) also exhibited concern over the lesson presentation, peer understanding and their joint implications. Statements such as

> "... now I'm not just concerned with myself. I'm concerned with the other people."
>
> "... we'd have to hurry up too or else we wouldn't get finished.
>
> "... everybody else will do it that way and they'll get confused too."
>
> "... it doesn't help anybody if I know it and nobody else does."

exhibited a degree of responsibility which this student assumed perhaps justifiably in view of the amount of help that s(he) anticipated might subsequently be requested of him (her) by his (her) peers.

A further insight into this pupil's view of classroom reality was touched upon by the teacher in the following teacher initiated dialogue in SRI-A-1.

T: I knew AA-1-2 would get it but s(he) hadn't had a turn yet, ay. So I ask him (her) and I don't make a big deal, oh whoopy that's really good AA-1-2 because it's so old hat. Everybody knows s(he) knows ... but s(he) doesn't have a problem about being awfully conceited about what s(he) knows. S(He)'s the brightest boy (girl) in my room, ay .... s(he)'s one of the brightest kids in the school .... and I don't make a big deal or overly praise him (her) or anything which I'm kind of careful not to do because I've heard ... s(he) doesn't have that problem with me this year but I've heard last year s(he) did.

I: Have what problem?

T: S(He) kind of was overly confident about what s(he) knew... I notice I kind of gloss over that, the way I responded to his (her) answer. It was a very fast answer and it was pretty complex compared to what we had been doing.

This student was asked one question in the two videotaped lessons. S(He) looked forward to doing the worksheets, helped his (her) peer friend during one lesson presentation and assisted many other peers in the class who requested help with their mathematics problems. A niggling concern remained with this investigator over the plight of this bright young student who may sit through seven more years of schooling during which time mathematics may lose its appeal through lack of challenge. Such a consequence represents a negligence of human potential. This same student physically displayed emotional distress during an SRI as he recalled his (her) thoughts and feelings relative to the incident in which s(he) had requested help from the teacher and during which the teacher made no verbal contact with him (her).

Student AA-2-1

This student disclosed the lowest number of interactive thought units (22) of all the pupils interviewed. A short discussion of this SRI can be found on page

Student AA-2-3

(a) Self-concept and Mathematical Confidence

Eight statements made by this student indicated personal confidence in his (her) mathematical ability. Three of those statements were as follows:

> "H(She)'s putting in her zeros. They don't even indicate anything but s(he) just puts them in."
>
> "I know I'm somebody here." (S(He) helps three or four peers in the class with their mathematics problems.)
>
> "I was done." (Only two other students had also completed their work.)

These statements were counterbalanced by six statements which indicated a certain amount of confusion regarding the mathematical concept being taught although two of these were made in reference to the large numbers used by student AA-1-2.

(b) Reflective Ability

Five reflections were disclosed in the three categories of CAPIT, MS, MT, and MP. These thought units constituted 7.4% of all this student's interactive thoughts.

(c) Introspective Ability

Four statements made by this student revealed a degree of introspection during the lesson. Two of these were as follows:

> "I tune them out."
>
> "I was puzzled though for a few seconds."

(d) Perceived Locus of Control

No explicit references to a lack of control over his (her) academic success in mathematics were made by this student nor did s(he) indicate any feelings of a lack of control over classroom events. However, s(he) sat beside a peer (AA-1-2) during the lesson presentation and relied upon his (her) help in preparing answers and his (her) judgement of the correctness of these answers to questions posed by the teacher.

(e) Mathematical Verbalization

The following statements made by this student exemplify the highest level of sophistication in his (her) expression of mathematical thinking.

> "It was adding and subtracting decimals."
>
> "It doesn't matter (if zeros are put in for subtraction purposes) because ... you need to change the 5 to 4 and zero to ten to subtract."

(f) Feelings

This student revealed the highest percentage distribution of feelings experienced during a single lesson of all students interviewed. Four of these nine thought units included the following:

> "I felt relieved (when the teacher said you don't need to put in the zeros)."
>
> "I wasn't really scared (when the teacher put an example on the board)."

> "I got kind of worried (when the teacher put in the zeros for subtraction)."
>
> "I was relieved (when the teacher didn't hand out worksheets) because I thought the sheets would be hard again."

Although the teacher did not ask this student to respond to any of the questions posed during the lesson, s(he) interpreted it as a sign that "s(he) knew that I knew how to do it."

The interviewee-interviewer 'initiation of dialogue' ratio was 4:14. All four student -selected nodes focused on him (her) self. Two of these were lesson content related. Pre-selected nodes for comparative purposes were used for interviewer initiation of dialogue during the SRI's following the videotaping of the second lesson presented by the same teacher. This student was interviewed once after the second videotaped lesson.

Student BB-1-1

(a) Self-concept and Mathematical Confidence

Thirty seven (20 + 17) statements made by this student in the two SRI's revealed personal confidence in his (her) mathematical ability. Statements such as the following indicated a very high level of confidence.

> "Whenever s(he) (the teacher) asks me a question I can come back with the answer."
>
> "I'm really good at assignments."

> "I know all about my fractions."
>
> "S(he) (the teacher) didn't really answer the question because I knew it."
>
> "I knew them if I hadn't been rushed."
>
> "I knew the answers."
>
> "I get so bored with it (Math) because I know most of the math."
>
> "I was the first one finished them (the assigned questions)."

More than any of the other eleven students interviewed, this student revealed his (her) self-concept in statements such as the following:

> "I can do anything I want in Math. I can fool around and I can get the answer right on.
>
> "I knew it (the math) so I don't pay attention to it."
>
> "I usually pick it (teacher errors) out first of all 'cause if there's a wrong answer, if I see an answer I don't like, usually it's wrong. I can pick out things like that."
>
> "I can just shut myself off from the rest of the world and get my work done and nothing else bothers me."
>
> "... a lot of times if I think something ... I won't change my mind. You can ask my mom and dad or the teacher. I don't change my mind for nothing.
>
> "... like when s(he) (the teacher) gives us questions I answer them right off the bat. Like I can do my own work right fast ... I'm usually the first to finish."

There were three statements made by this student indicating confusion relative to the mathematical content of the lesson. One related to a pupil initiated question, one to his (her) inability to list the answers faster than the teacher, and the last one to a question posed by the teacher to the whole class regarding the use of fractions.

(b) Reflective Ability

Twenty-one (13 + 8) reflections were disclosed by this student in the two SRI's. They constituted 5.8% of all his (her) interactive thought units in the two videotaped lessons. Of these, 2.5% were in the MS category, 3% in the MT category and 0.3% in the MP category, a distribution congruent with his (her) minimal focus on his (her) peers.

(c) Introspective Ability

Forty-five statements (21 + 24) revealed this student's awareness and monitoring of his (her) cognitive functioning during the two videotaped lessons. Among these were the following:

> "I wasn't really thinking of the question."
>
> "So I was thinking unpleasant thoughts about (the teacher)."
>
> "But then I got back to my work and just shut myself off."
>
> "So I just block it out (of my mind)."
>
> "I shut myself off and did the questions."
>
> "I answered the questions in my brain."
>
> "I was not really keeping my mind on it."

This student monitored his (her) own levels of attention and concentration at various points in the lessons and varied them according to his (her) perceived need for concentrating on the lesson procedures. His (Her) major purpose was to pay as little attention as possible but at the same time not be caught unprepared to answer a question directed to him (her) by the teacher.

(d) Perceived Locus of Control

This student exhibited a very high degree of mathematical confidence and an explicit 'internal' locus of control over his (her) academic success in mathematics. S(He) also disclosed an 'internal' locus of control over classroom events to the extent that s(he) tuned out what s(he) found uninteresting, monitored the teacher's actions frequently to detect teacher errors and otherwise entertained him (her) self as best s(he) could to ward off boredom. While s(he) disclosed that s(he) could do anything s(he) wanted to in Math including 'fooling' around, s(he) did make notes, proffered answers, worked at problems in the text, and asked complex questions of the teacher to which s(he) already had the answers. As did student DD-1-2, this student worked intermittently during the lesson presentations on problems from the text in the same unit of study. These problems s(he) anticipated having to do orally in class as a group or individually as part of an assignment. Consequently in lesson two, s(he) had already done the questions on fraction of girls and boys in the text picture and so "just sat back and listened."

In one instance (lesson one) s(he) expressed dissafisfaction with the lesson content. That is, s(he) would have preferred lessons on decimals as s(he) felt s(he) knew the work being presented. A perceived 'external' locus of control was evident in frequent thought units relating to the degree of his (her) overt participation in the lessons. S(He) expressed disappointment at not being asked to do a problem at the board or provide a problem to be worked at the board by his (her) peers. S(He) also rationalized not being asked more questions by the teacher as being due to his (her) knowledge of the correct answers.

(e) Mathematical Verbalization

The following two statements made by this student exemplify the highest level of sophistication in his (her) expression of mathematical thinking in the two SRI's.

> "There couldn't be a greatest common multiple because you could go on forever."
>
> "... mainly because you're subtracting 20% off $50.00, so make that a fraction."

(f) Feelings

Twenty-three (17 + 6) instances of emotion experienced during the two videotaped lessons were revealed by this student. Of these, 19 were related to teacher actions during the lesson. The only emotions related to his (her) peers were two instances of embarrassment and one of being upset. The embarrassment was over not getting the correct answer to a question but it was not clear even from the context whether these two feelings were perhaps more directly related to the teacher than to his (her) peers. S(He) was upset over two peers talking while s(he) was doing his (her) work. In ten of the 23 feelings, s(he) experienced varying degrees of boredom from "just bored" to "really extremely bored", in two embarrassment, in three, disappointment, in two, worry, in two, being upset or mad, in three, equanimity, and in one, enjoyment over making a "fool" of the teacher.

The interviewee/interviewer 'initiation of dialogue' ratio was 22:1 in the first SRI and 12:8 in the second. The student selected nodes in the two SRI's focused on him (her) self (17/34), the teacher (8/34), his (her) peers (3/34), lesson content (3/34) and ecological factors (3/34). This student exhibited a 'consistent' high percentage frequency of MS thought units in the two SRI's. Both percentage frequencies in the ME-I and ME-II categories were lower than the average pupil percentage frequencies in these categories yet, this student asked one or two high level questions of the teacher in both lessons and answered them him (her)self. Nor did s(he) monitor his (her) peers to any great extent. S(He) revealed considerable interest in the videotaping of the lessons. The three nodes chosen by the student and classified as ecological in focus were concerned with the presence of the camera in the room. S(He) frequently looked back at the camera "because I wanted to see what the camera was like ..." S(He) was responsible for the daily transportation of A-V equipment to and from the classroom and stated, "None of the A-V machines are actually interesting except the TV cameras."

This student placed his (her) judgement of lesson content on a par with the teacher and occasionally above that of the teacher. Some of his (her) statements included the following:

> "S(He) (the teacher) didn't really answer the question because I knew it."
>
> "S(He) (the teacher) made a mistake him (her)self, like s(he) said ... the greatest common multiple. And so s(he) made a fool out of him (her) self and I was kind of, you know, I kind of enjoyed it. But I like (the teacher). I'm happy when (the teacher) makes a fool of him (her) self... in geometry like s(he) was doing them wrong and I told him (her) how to do it right..... _____ (a peer) and I, we're always correcting him (her) ... well I enjoy it because a grade 6 student making ... smarter than the teacher. It makes me feel good 'cause I'm picking it up and s(he) (the teacher) isn't."

This same student was highly critical of the teacher and his (her) instructional behavior both in math and in other subject areas. According to him (her) the teacher does not make errors intentionally. S(He) monitors the teacher for errors in vocabulary and pronunciation as well as errors in mathematical terminology and concepts. S(He) made the following comments about the teacher.

> "Like s(he) doesn't listen. S(He) asks us and then s(he) (does them) him (her)self."
>
> "S(He) made a mistake so s(he) made a fool of him (her)self."
>
> "If a grade 6 student is correcting the teacher of the class s(he)'s not doing something right."
>
> "S(He) was really feeling bad. I asked him (her) a question (just before class) and s(he) didn't know it. And I answered it 'cause I'd already figured it out."
>
> "We try to embarrass him (her). Me and _____(a peer) just drive him (her) up the wall 'cause we're always correcting him (her).
>
> "... if I don't think they're right on the board, I'll put them into my own sentences so I understand them better."

This student professed a lack of interest during most of the two lesson presentations. Very early in the first lesson s(he) expressed boredom and frequently disclosed that s(he) was paying little or no attention to the lesson presentations. S(He) revealed that in addition to tapping his (her) feet and/or his (her) hands when s(he)'s bored, "I just don't pay attention." S(He) stated that "the only time I don't feel bored during the lesson is when s(he) gives us the assignment.".

A comparison between student AA-1-2 and BB-1-1 revealed a degree of intellectual arrogance in both but particularly in the latter. Whereas student AA-1-2 made the comment, "Everybody should know 7 + 5 is 12", it was the only indication of this phenomenon in his (her) two SRI's. Student BB-1-1 however made frequent statements in the SRI's about his (her) mathematical prowess and in several instances referred to certain peers in the class as 'dozers' or 'sieves'. When no one raised a hand for the wrong answer s(he) made the comment during the course of the lesson, "It's good to see that all you guys are smart."

While s(he) compared his (her) mathematical ability to those of his (her) peers implicitly through references to them as 'dozers' or 'sieves' and prided him (her)self on being the first or among the first to complete the assigned work in math, his (her) focus on the teacher and his (her) own relationship with the teacher appeared to be upper-most in his(her) mind. S(He) was often critical of the teacher, considered him(her) self more capable than the teacher in mathematics and yet professed not to mind when the teacher requested him(her) to stop answering questions. S(He) also disclosed thought units indicating that s(he) was attempting to nuture an adult relationship with the teacher. S(He) made comments during the lesson such as the following:

> "It's not even August yet M _____" (Made in reference to a teacher error in terms.)
>
> "Are they?" (Made in reference to a teacher admonition to two students.)

When asked if s(he) thought the teacher heard any of these remarks s(he) replied, "Oh, s(he) heard me. I 'jive' him (her) a lot of times." In spite of this student's professed boredom during math lessons, s(he) disclosed that he (she) enjoyed school. The teacher did not interpret this student's comments or classroom behaviors as malicious and the two of them seemed to enjoy a good relationship. During the first lesson the teacher good-naturedly teased this student about staying in at recess time and the student responded in kind. Student BB-1-1 also disclosed that s(he) liked his (her) teacher.

A curious phenomenon occurred during the second videotaped lesson. The teacher interrupted his (her) remarks to say "Don't". Student BB-1-1 and student BB-1-2 (as well as the teacher) perceived this comment as being directed to student BB-1-1 and interpreted it to mean that student BB-1-1 had been answering too many questions without being asked for a response by the teacher. Thought units disclosed by student BB-1-1 throughout the second SRI were frequently made in reference to this incident. Some of these units include the following:

> "I couldn't answer the questions anymore. S(He) (the teacher) went on to somebody else."
>
> "S(He) didn't want me to answer it because s(he) knew I knew it."
>
> "If s(he) (the teacher) asked me, it didn't really

> matter to me then if s(he) did or didn't ask me."

This student did occasionally answer a question later in the same lesson without being asked to respond as did several other students. At one point s(he) made the comment, "I blurted out an answer ... then I just thought the answer really wasn't counted." Later when s(he) raised his (her) hand to answer and a peer "blurted it out," s(he) said, "I was a little bit disappointed but not much "cause it didn't really matter to me." Later at a student chosen node s(he stated, "Well, here s(he)'s picking people for the -- to come up and do some questions and I wanted to be picked to go up there. I put up my hand before anybody else and I still didn't get picked. And then later on, right after this s(he) picked somebody to give people numbers and I wanted to give the numbers to (a peer) but s(he) wouldn't let me --- a little mad." When asked if s(he) gets turns to go to the board and to do other things s(he) responded, "I get turns, like s(he) asks me questions but I don't get asked very often. I get asked maybe once during a lesson or once or twice during a lesson just to make sure that I'm paying attention because s(he) knows I know the answers to them all." This student's strategy for both lessons was to pay just enough attention to be able to answer the odd question asked of him (her). S(He) spent his (her) time occasionally making his (her) own notes, correcting the teacher, talking to a student seated next to him (her), playing with math resource materials or tapping his (her) hands and/or feet. While s(he) professed to be bored most of the time and his (her) SRI's revealed low levels of peer monitoring and in one SRI a low level of teacher monitoring, his (her) recall of classroom events was accurate. This same student exhibited a restlessness during the SRI's. Although s(he) viewed the tapes in detail and openly disclosed his (her) interactive thoughts, s(he) continuously teetered on his (her) chair and fidgeted with anything within reach.

Student BB-1-2

(a) Self-concept and Mathematical Confidence

Eighteen statements made by this student in the first SRI and seven in the second revealed his (her) self-concept and/or mathematical confidence. Statements such as the following indicated this student's confidence in his (her) mathematical ability.

> "I was thinking that if I went up there I could have got it right."
>
> "I was the second one done."
>
> "I knew it (the answer) but I didn't put up my hand."
>
> "I figured it out because the left-over piece was smaller."
>
> "Well, (a peer) answered the right answer even though there was no such thing."

"I figured it out."

"I knew the answer."

There were four (1 + 3) statements made by this student indicating confusion relative to the mathematical content of the lesson. In one instance the pupil was trying to get the answer before anyone else could and failed to do so. In the second lesson s(he) admitted not knowing much about the lesson content prior to the lesson, initial confusion over the different sized 'pie' diagrams on the board and that s(he) had counted the children in the text picture incorrectly.

(b) Reflective Ability

Twenty-seven (8 + 19) reflections were disclosed in the three categories MS, MT, and MP of CAPIT. These thought units constituted 11.8% of all his (her) recalled interactive thoughts. Of these 4.3% focused on his (her) peers, 7% on him (her)self and 0.4% on the teacher.

(c) Introspective Ability

Ten statements revealed student awareness and monitoring of his (her) cognitive functioning during the lessons. Three of these statements were,

"I was off the lesson."

"I was trying to think back more."

"I didn't understand what he (a peer) was thinking about."

(d) Perceived Locus of Control

This student revealed an 'external' (perceived) locus of control over classroom events in three instances. S(He) expressed disappointment over not being asked to respond to questions and to either do a problem on the board or choose a problem to be solved at the board. S(He) also exhibited overt attempts to gain the teacher's attention in order to get a chance to respond. However s(he) did admit that, "actually I get asked a lot to do stuff for him (her) (the teacher)". This student also disclosed an impatience with the slow pace of the lesson and a concern over the math work assigned as s(he) had extra curricular activities after school which s(he) anticipated having to miss because of the accumulation of assignments in other subjects as well. Although s(he) noticed the differences in the pie sizes on the board, s(he) was reluctant to point out this difference and instead managed to get the right answer and to understand the fractions being compared by comparing the remaining portions of the two circles. In another instance this student explicitly exhibited an 'internal' locus of control regarding his (her) error in attempting to get the answer to questions posed by the teacher. The student was getting different answers to questions relating to a picture in the text and realized that s(he) had counted the number of children in the picture incorrectly. S(He) did not attribute his (her) error to the textbook or the teacher even though other students were having difficulty distinguishing the boys from the girls in the picture. In general s(he) exhibited an 'internal' locus of control over his (her) academic success in mathematics.

(e) Mathematical Verbalization

The following statements made by this student in the ME-II category of CAPIT exemplify the highest level of sophistication in his (her) expression of mathematical thinking or understanding during the SRI's.

> "... like we had to get the prime factorization for 26."

> "I was trying to figure out if 8 times 10 would be the lowest common multiple."

(f) Feelings

This student revealed 10 instances of emotions experienced during the two lessons videotaped (7 + 3). Of these, two expressed boredom, two embarrassment, two disappointment, three that s(he) was upset or mad, and one in which s(he) felt good about getting a correct answer.

The interviewee/interviewer 'initiation of dialogue' ratio was 11:9 in the first SRI and 4:10 in the second. The student selected nodes focused on the teacher (5/15), him (her)self (6/15), his (her) peers (3/15), and ecological factors (1/15). During the two SRI's this student disclosed three extraneous thought units, four ecological, and two units of irrelevant information. These thoughts collectively represented 3.9% of all interactive thought units recalled by this student in the two SRI's. Three of the ecological thought units all referred to the VTR equipment. The other thoughts related to basketball practice (2), floor hockey (1) and baking after school (2).

This student exhibited a 'consistent' high degree of self-monitoring and peer-monitoring in the two SRI's. More than any other student interviewed, this particular student pondered over the behaviors of his (her) peers and the teacher. These attempts to 'see' into the mind of others were revealed in a number of statements as follows:

> "I was wondering why he (a peer) got onto the subject of 20% off %50.00."
>
> "I don't know why she (a peer) would think of a whole bag of flour."
>
> "Why is the teacher reviewing us again?"
>
> "I thought s(he) (the teacher) was trying to make the class, well kind of be good because we were on videotape. S(He) usually lets us talk a lot."

S(He) also compared his (her) mathematical ability to those of his (her) peers. S(He) attempted to get answers to questions before his (her) peers were able to do so. S(He) "felt dumb" because his (her) peers in close proximity were able to recall more of last year's mathematical terminology relating to fractions than s(he) could. Yet when three of the four students had difficulty with the problems at the board s(he) was confident that s(he) would have been able to do one correctly.

This student's intent in both lessons was to monitor the lesson presentation and his (her) own understanding of the concepts being taught. S(He) did have fleeting thoughts about matters extraneous to the lesson content, however his (her) intent was to learn as much as possible and to get his (her) assignments completed in class. Although s(he) was aware of the VTR and camera in the classroom, this awareness was more personally distracting in the first lesson than in the second. In the first lesson s(he) disclosed that s(he) noticed the camera when s(he) entered the room but forgot about it during the lesson until s(he) happened to look back and noticed it again at which time s(he) decided to stop 'shouting out' answers as many others in the class were doing. On two other occasions s(he) expressed his (her) desire to sound good on tape when s(he) answered a question and his (her) desire to do a question at the board so s(he)'d be on camera. In the second lesson, this awareness of the camera was more objective in that the only two times s(he) disclosed awareness of it was in relation to a teacher overt action which s(he) considered abnormal due to the videotaping and a concern over the darkness of the room during the use of the overhead projector which might adversely affect the videotaping.

Student CC-1-1

(a) Self-concept and Mathematical Confidence

Five statements made by this student indicated personal confidence in his (her) mathematical ability. Three of these were as follows:

> "I knew it."
>
> "I got it right."
>
> "I was thinking I betcha I could do it the short-cut way."

There were three statements made indicating confusion relative to the mathematical content of the lesson. Two related to one problem which s(he) never did get right and the other to a problem s(he) was trying to construct.

(b) Reflective Ability

Five reflections were disclosed in the two categories MS and MP and none in the MT category. These thought units constituted 9.6% of all his (her) recalled interactive thoughts. The three reflections in the MP category were all related to a class contest.

(c) Introspective Ability

This student exhibited a low level of introspection. Only one statement in the SRI revealed student awareness and monitoring of his (her) cognitive functioning during the lesson. S(He) disclosed that s(he) "didn't quite know" what the teacher was doing relative to a discourse on the rules of the contest.

(d) Perceived Locus of Control

Implicitly, this student exhibited an 'internal' locus of control relative to both his (her) academic success in mathematics and to classroom events. S(He) had been absent for a week of skiing and also the previous day. The teacher monitored his (her) work closely and s(he) was able to get all but one of the problem answers correct.

(e) Mathematical Verbalization

The following statement made by this student exemplifies the highest level of sophistication in his (her) expression of mathematical thinking during the SRI.

> "I'm going to use both ways only in the hard ones I'm going to take the short cut."

(f) Feelings

This student revealed two instances of emoticns experienced during the lesson. One of these expressed happiness when the students won points in the contest and the other that s(he) was "sort of scared" about his (her) pending surgical operation.

The interviewee/interviewer 'initiation of dialogue' ratic was 6:5. The student selected nodes focused on him (her)self (3/6), the teacher (1/6), lesson content (1/6) and on ecological factors (1/6). S(He) disclosed early in the SRI that s(he) was concerned about a surgical operation s(he) was to undergo the following Monday and had interactive thoughts about his (her) birthday party which was to be celebrated before hospitalization. Although s(he) had missed a considerable amount of math work through absenteeism, with the help of the teacher and his (her) strong focus on the mathematical content of the lesson, s(he) was able to master most of the work. S(He) admitted not being able to discover a strategy for constructing a division problem that would have a zero in the quotient but felt confident that with his (her) father's help s(he) would be able to complete the assignment. His (her) monitoring of peers was limited to their collective ability to win points in the contest.

Student CC-1-2

(a) Self-concept and Mathematical Confidence

Twenty-three statements made by this student in the recall data (11 + 13) indicated a high level of confidence in his (her) mathematical ability. Several of these were as follows:

> "That meant he needed an extra shelf."
>
> "The right answer was 807."
>
> "It was a marble not a bag left over."
>
> "If you do check, you've got it right."

"I got it before."

"I did it with both (methods)."

"You can't do it that way."

While there were no statements made in either SRI indicating confusion relative to the mathematical content of the lesson s(he) did miss the significance of one incident by relying on the teacher's remarks instead of exercising his (her) own judgement.

(b) Reflective Ability

Seventeen reflections were disclosed in the three categories MS, MT and MP of CAPIT. These thought units constituted 11.6% of all this student's interactive thoughts during the two lessons videotaped.

(c) Introspective Ability

Four statements (3 + 1) revealed student awareness and monitoring of his (her) cognitive functioning. Two of these statements were

"I didn't know how to put it into words."

"I wasn't paying too much attention."

(d) Perceived Locus of Control

This student revealed an implicit 'internal' locus of control relative to both his (her) academic success in math and to classroom events. S(He) did disclose that a peer tended to copy his (her) answers but generally reacted to all classroom incidents with equanimity. Even when the teacher failed to detect or acknowledge that s(he) had solved the problem using two methods instead of one, s(he) revealed no concern.

(e) Mathematical Verbalization

The following statement made by this student exemplifies the highest level of sophistication in his (her) expression of mathematical thinking in the two SRI's.

> "You've got seven 8's in 72 and you have to make the next number smaller so it'll be a zero."

This statement was made in connection with his (her) self-conceived strategy for constructing a division question with a zero in the quotient.

(f) Feelings

Six instances of emotion experienced during the two lessons videotaped were revealed in the two SRI's (4 + 2). Three expressed happiness, one surprise that the whole class got the first problem correct and one that s(he) hadn't been feeling well. In one statement s(he) disclosed that s(he) was both mad and happy - mad that s(he) hadn't provided a better explanation and happy that the teacher had accepted his (her) answer.

The interviewee/interviewer 'initiation of dialogue' ratio was 11:3 in the first SRI and 4:17 in the second. Student selected nodes in the first SRI focused on him (her)self (4/11), peers (5/11), lesson content (1/11) and ecological factors (1/11). In the second SRI they focused on his (her) peers (4/4). This student exhibited 'on task' behaviors during both videotaped lessons. His (her) frequencies of mathemagenic behaviors during both lessons were high (35.4% and 47.1%). S(He) not only exhibited a high level of mathematical confidence but also revealed in the SRI's, a thorough understanding of the concepts taught. S(He) was able to independently construct division problems with a zero in the quotient, obtain correct answers to the problems independently during the lessons, interpret remainders correctly within the problem contexts and through consistent checking of his (her) answers was aware of their accuracy. This last factor may have accounted for the low level of introspection revealed by this student.

On the basis of his (her) mathematical competence and independent thinking, s(he) revealed a higher than expected reliance upon teacher directions in one instance. When a peer proffered a division problem which would result in a 4-digit quotient and the teacher remarked that the students wouldn't be able to do it because s(he) hadn't taught it yet, this student (CC-1-2) reiterated what the teacher had said. Yet s(he) should have been capable of solving the problem. Of significance in the second lesson videotaped, was this student's absence of resistance to the learning and use of additional methods for solving similar problems, a phenomenon not common to the majority of the students in the class.

Student CC-1-3

(a) Self-concept and Mathematical Confidence

Seven statements made by this student in the two SRI's indicated personal confidence in his (her) mathematical ability (3 + 4). Several of these were as follows:

> "I got the right answer."
>
> "S(He) (the teacher) was doing the old method."
>
> "She (a peer) said the wrong number and well, it was away off."
>
> "I thought it was probably right."

These were counterbalanced by nine statements which indicated confusion relative to the mathematical content of the lessons. Three of these were as follows:

> "I didn't think that you could add a remainder of one onto 905."
>
> "I tried the new method and I got mixed up on it."
>
> "I did the old method and it still didn't work."

The first of these statements was in reference to the interpretation of a remainder in a problem context where the answer was based on logic rather than numerical computation.

The remaining eight referred to instances when this student either didn't know how to do the problem, made computational errors or didn't fully understand the concept or procedure.

(b) Reflective Ability

Fifty reflections were disclosed by this student in the three categories MS, MT and MP of CAPIT. These thought units constituted 15.8% of all this student's interactive thoughts, the highest proportion of reflections disclosed by the twelve students interviewed.

(c) Introspective Ability

Eight (6 + 2) statements revealed student awareness and monitoring of his (her) cognitive functioning during the lessons. Three of these were:

"I guess I wasn't thinking then."

"I didn't know how to do it."

"I got caught in this spot."

(d) Perceived Locus of Control

S(He) revealed an implicit 'internal' locus of control relative to his (her) academic success in math in that s(he) blamed neither teacher behavior nor external factors for his (her) lack of success. A somewhat 'external' locus of control relative to classroom events was exhibited by his (her) disclosure particularly in the second SRI. Five statements made by this student revealed a lack of control over classroom events. These were related to three different incidents which occurred during the lesson. In the first one s(he) was being bothered by a peer, in another s(he) complained about the limited number of questions s(he) was asked to respond to by the teacher and his (her) bad luck in not drawing teacher questions to which s(he) knew the answers. In the last incident s(he) revealed that his (her) peers received credit for an answer which s(he) had stated earlier. Some of his (her) statements were as follows:

> "...I thought I would have got a turn (to answer) and I didn't... I got to say some stuff but not as much ... I had lots of answers and like when I got a chance to answer it was something I didn't know and sometimes I knew it and I didn't get asked."
>
> "... I said, "You must have left a tip." And well s(he) (the teacher) didn't hear me.
>
> S(He) thought I said something else maybe. And those other guys heard me and when I said a tip and they said it. And s(he) (the teacher) said "Very good." and they got the credit."

In the first SRI this student made the remark, "I finally get to be in a problem.". This was made in reference to a peer proffered question to be solved in which the student's name was used in the problem context.

(e) Mathematical Verbalization

The following statements exemplify the highest level of sophistication is his (her) expression of mathematical thinking during the SRI's.

> "When I finished I figured out I didn't have a zero in the quotient."
>
> "When s(he) (the teacher) checked it s(he) had to add another 8."

(f) Feelings

This student revealed 9 instances of emotions experienced during the two lessons videotaped (3 + 6). Of these two expressed relief when a peer finally finished a problem and when s(he) (student CC-1-3) found out that they wouldn't be tested on the new method being taught. There were two expressions of feeling 'glad' when s(he) managed to get correct solutions to problems worked on during the lessons and four expressions of feeling 'bad', three when s(he) couldn't construct a question correctly, wasn't asked a question by the teacher, and didn't get credit for an answer and one when s(he) was called a 'name' by a peer. In one instance s(he) felt embarrased when s(he) couldn't get an answer as quickly as his (her) peers.

The interviewee/interviewer 'initiation of dialogue' ratio was 3:4 in the first SRI and 10:13 in the second. The proportion of segments per pages of recall data was low for once dialogue was initiated this student persistently recalled all that s(he) possibly could and then stopped.

The student selected nodes focused on his (her) peers (2/3) and himself (1/3) in the first SRI and on his peers (5/10), himself (2/10), the teacher (2/10) and lesson content (1/10) in the second. While this student's mathemagenic behavior in both lessons was fairly high (39.0% and 33.3%), and he was able to get the correct answers eventually for all but one problem solved during the lessons, he did not exhibit (in the SRI's) a strong grasp of the concepts taught nor an understanding of the subtler lesson objectives. In the first videotaped lesson, this student failed to understand the interpretation of remainders within the problem context, was unable to construct a division question with a zero in the quotient, chose not to try a shorter method explained by the teacher, needed help from a peer to solve one problem and although s(he) didn't think one answer was sensible, conceded that it must be right "because the teacher agreed with it too and when s(he) agrees, it's probably right."

In the second lesson, this student was unable to use the newly explained partial quotient method for division correctly, made a number of errors in solving the problems even using the old method for division, tended to be slower than many students in getting verbal answers to questions and although s(he) competently judged the merits of some of his (her) peers' interpretations of a remainder in one problem context, once again s(he) ceded to a misconception that one of the answers with which the teacher seemed to be in agreement had to be the only correct response.

This student seemed to be experiencing information overload during the two lessons for he recalled in minute detail, interactive thoughts which revealed the high degree to which s(he) monitored his (her) peers, the teacher, and him (her)self. The frequency and breadth of his (her) reflections attest to the fact that s(he) was processing a great deal of information (during the lesson presentations and particularly during the second lesson) which was predominantly irrelevant to the lesson focus and at best indirectly related.

S(He) exhibited a tendency to resist new methods and concepts, expressed a concern over the level of difficulty of problems, questioned the teacher about whether they'd be tested on the partial quotient method even before it had been taught, and gauged the correctness of many answers on the basis of his (her) teacher's and his (her) peer's opinions. Yet this student revealed in the SRI's but not during the lessons that while he was capable of analyzing mathematical situations, s(he) didn't trust his (her) own judgement as well as that of others. In surmising where the quotient in the partial quotient method might be placed, his (her) first intuition was correct but s(he) refrained from disclosing his (her) opinion until student CC-1-4 had suggested the same location. In the interpretation of an eight dollar remainder in box office receipts s(he) suggested first that it might be a tip. His (her) assessment of a peer suggestion that someone forgot to take the ticket was, "but why would someone buy a ticket for nine dollars and then forget the ticket?". S(he) concluded that someone must have left a tip because "that's what the teacher said." But soon after s(he) may have begun to doubt it for s(he) stated, "then (   ) butted in and said, "But that's impossible 'cause no one would ever leave an 8 dollar tip."". S(He) also completely missed the significance of why the teacher chose to treat the partial quotient method of division as an alternative method for division in grade four.

While this student possessed a cheerful demeanor and frequently found humor in classroom incidents, s(he) seemed somewhat disoriented to certain classroom procedures. Although s(he) had been a member of this class with the same teacher since fall, s(he) seemingly did not yet know the contest rules. In one instance when s(he) attempted to help a peer in the same row, s(he) was asked to desist by the teacher. On another occasion s(he) received a hint from a peer in the same row in solving a problem but felt that s(he) had cheated when s(he) held his (her) hand up to indicate to the teacher that s(he) had obtained the correct answer.

The teacher disclosed later that during the contest, students were allowed help from the teacher and help from peers in the same row unless s(he) specifically directed them to do otherwise.

When questioned about his (her) assignment following the first videotaped lesson, this student indicated that s(he) would try and do it on his (her) own because "we're supposed to be doing it.". Yet student CC-1-1 disclosed that s(he) (CC-1-1) would be working on his (her) assignment with his (her) father.

An indication of student CC-1-3's level of maturity was evidenced in the SRI's by the manner in which s(he) referred to his (her) teacher. On at least four occasions s(he) referred to him (her) as "teacher said" or "teacher did" instead of 'the teacher' or "Mr(s) _____. Some phrases were as follows:

> "... before teacher could finish it."
> "... that's what teacher said."
> "... that teacher didn't notice it."

In addition to his (her) detailed recall of classroom events and monitoring of many peers, this student also disclosed that s(he) sometimes draws pictures during lesson presentations and in the second videotaped lesson was worried about "getting into trouble" at his (her) noon Art club over missing the last meeting. In view of his (her) extensive and accurate recall it is not surprising that s(he) paid no heed to the VTR equipment in the room but unfortunate that his (her) information processing capacity was not channelled more productively.

Student CC-1-4

(a) Self-concept and Mathematical Confidence

Twenty-three (12 + 11) statements made by this student in the two SRI's revealed a high degree of confidence in his (her) mathematical ability. Some of these statements were as follows:

"I got it right."

"And of course, I was right."

"I checked it and it was right."

"I knew it was between 109 and 999."

"I used the new method."

There were three statements made by this student indicating confusion relative to the mathematical content of the lessons. S(He) admitted not knowing the answer to a question although in this instance his (her) answer was equally valid. S(He) didn't understand a short method of division explained by the teacher and didn't understand why the teacher remarked that the students wouldn't be able to handle a certain division question.

(b) Reflective Ability

Sixteen (9 + 7) reflections were disclosed in the three categories MS, MT and MP of CAPIT. These thought units constituted 9.5% of all his (her) recalled interactive thoughts.

(c) Introspective Ability

Five statements revealed student awareness and monitoring of his (her) cognitive functioning during the lessons. Three of these were:

"The answer came to me."

"I didn't have to feel guilty."

"I was pretty sure I was right."

(d) Perceived Locus of Control

This student revealed implicitly an 'internal' locus of control relative to both his (her) academic success in math and to classroom events.

(e) Mathematical Verbalization

The following statements made by this student exemplify the highest level of sophistication in his (her) expression of mathematical thinking in the two SRI's.

> "It was easier just to work it out to the place value."
>
> "Well, the first two numbers have to be a basic fact to get a zero."

(f) Feelings

This student revealed 9 instances of emotion experienced during the two videotaped lessons (8 + 1). Of these, six expressed gladness, five over getting correct answers and one because s(he) wasn't talking when the teacher reprimanded the class. One expressed surprise when the whole class got the correct answer to a problem, one disappointment when the class lost points to the teacher, and one in which s(he) felt 'stupid' when s(he) didn't know the answer to a problem.

The interviewee/interviewer 'initiation of dialogue' ratio was 11:2 in the first SRI and 13:8 in the second. The student selected nodes focused on him (her)self (6/11), his (her) peers (4/11) and lesson content (1/11) in the first SRI and on him (her)self (2/13), his (her) peers (1/13), lesson content (9/13) and on the teacher (1/13) in the second SRI. This student revealed a high degree of mathemagenic behavior (46.3% and 51.1%) in the recall data and exhibited 'on task' behaviors during the lesson presentations. S(He) was able to give a succinct and correct interpretation of a remainder in the first problem solved and although the students expressed a desire for the teacher to ask him (her) to interpret another remainder s(he) disclosed in the SRI that s(he) did not have the right answer. However his (her) suggestion was valid to the extent that various interpretations could be correct and s(he) was cognizant of this relative to this problem and to other similiar problems.

S(He) exhibited a high degree of mathematical confidence and in one instance revealed that s(he) placed his (her) judgement of the correctness of answers on a par with that of the teacher's. S(He) was the only one of the four students interviewed after the first videotaped lesson who revealed a thorough knowledge of the contest rules for scoring. Although s(he) obtained correct answers for all the problems, the class lost points on one problem since one or more of the students failed to get the correct answer. Although s(he) expressed disappointment over this s(he) said, "but you can understand that some people just can't get it right all the time.". This was said in earnest as though by one adult to another with no hint or arrogance or conceit. While s(he) monitored his (her) peers in both lessons, the focus was predominantly related to lesson content.

Student DD-1-1

(a) Self-concept and Mathematical Confidence

Five statements in the first SRI and eight in the second SRI made by this student revealed confidence in his (her) mathematical ability. Statements such as the following indicated pupil control over his (her) learning process.

"I understood it."

"Really, it was sort of easy."

"I was right."

"I knew you couldn't divide by three."

"(The method) is sort of inaccurate but you get more work done that way."

There were four statements made by this student in the first SRI and none in the second indicating confusion relative to the mathematical content of the lesson. Two of these were related to the assigned questions, one to a question worked in class for which s(he) initially got the wrong answer and one to a lack of understanding of why the teacher presented two ways of representing multiples.

(b) Reflective Ability

Thirty-three reflections were disclosed in the three categories MS, MP and MT of CAPIT. The majority of these thoughts were focused on prior peer (19/33) and his (her) own personal behavior (22/33). These reflections constituted 9.8% of all this student's interactive thoughts.

(c) Introspective Ability

Eleven statements in the two SRI's revealed student awareness and monitoring of his (her) cognitive functioning. Three of these were:

"I sort of dozed off."

"Then, well I knew I must have been learning."

"I sort of got distracted from the work."

(d) Perceived Locus of Control

Although this student did not exhibit a high degree of mathematical confidence s(he) revealed an 'internal' locus of control over his (her) academic success in mathematics. S(He) disclosed a waning interest in math and a decreasing achievement level compared to his (her) math marks in earlier grades. While s(he) was easily distracted from the lesson focus and made occasional errors in his (her) work s(he) did not attribute his (her) errors or lack of success to the teacher or to external factors.

Three statements made by this pupil indicated an 'external' (perceived) locus of control over classroom events. S(He) wanted to stop the lesson presentation but waited for a peer to intervene. In two instances s(he) matter of factly stated that s(he) would not likely be asked by the teacher to respond to questions. In the first instance s(he) said, "It's almost never me." and in the second s(he) said, "So s(he)'d never ask me." Yet this student was one of three students who were asked to solve a problem on the overhead.

(e) Mathematical Verbalization

The following statements made by this student exemplify the highest level of sophistication in his (her) expression of mathematical thinking.

> "He was rounding off 29 to the nearest multiple of ten."

"It could be either a multiple of ten or a multiple of five."

(f) Feelings

Five instances of emotion experienced during the lessons videotaped were revealed in the two SRI's (3 + 2). Two of these expressed boredom with the lesson, one embarrassment over his (her) hiccoughs, one relief over the lesson presentation ending, and one of tiredness during the Monday lesson. This student exhibited a 'consistent' pattern of low frequency in the 'Feelings' category (1.9% and 1.2%). In fact, these two were among the five lowest frequencies in this category.

The interviewee-interviewer 'initiation of dialogue' ratio was 27:0 in the first SRI and 22:4 in the second. Student selected nodes in the first SRI focused on the teacher (1/27), him (her)self (8/27), lesson content (1/27), his (her) peers (2/27) and on ecological factors (15/27). In the second SRI pupil selected nodes focused on the teacher (2/22), him (her)self (6/22), lesson content (1/22) , his (her) peers (3/22) and on ecological factors (10/22). This student exhibited the highest percentage frequencies (21.9% and 21.4%) of EC interactive thoughts. Of the 71 'Ecological' interactive thought units in the two SRI's, 49 were related to the videotaping and interviewing, 6 to the length of the lesson presentation, 5 to time and 11 to distracting factors.

Discounting his (her) interest in the videotaping and interviewing, the remaining 22 interactive thoughts in this category constituted 6.7% of all his (her) interactive thoughts. This student revealed considerable interest in the videotaping during the familiarization phase as did a number of other students who were interviewed; however, s(he) was the only student who maintained a high level of interest throughout the two videotaped lessons. S(He) made no attempt to hide his (her) interest but when questioned at the beginning of the second SRI responded as follows.

> I: "Did it (the possibility of another interview) make any difference to your lesson?"
>
> S: "Ah, it didn't really. It didn't really interfere with the lesson as much as it did last time. Like, as a matter of fact it barely did at all."

Nevertheless, 24/173 of his (her) interactive thoughts during this lesson centered on whether s(he) would be interviewed again, how long the interview would be, whether s(he) could help move the VTR equipment, whether the camera was still on and whether the teacher would make the lesson presentation longer because of the videotaping. S(He) was also concerned about how his (her) peers would react to the videotaping.

This student disclosed that s(he) was often distracted during the two lessons by other peers, adults in the hall, classes changing and a patrol belt under his (her) desk.

When s(he) revealed considerable interest in the videotaping near the beginning of the first SRI, the following dialogue occurred.

> I: So you were quite interested in the camera today?
>
> S: Yeah.
>
> I: Did it distract you from the lesson at all?
>
> S: Well, a bit but not much, not much more than usual.
>
> I: What do you mean by not more than usual?
>
> S: Well, usually the lessons get usually so long I'm distracted by somebody else anyway, by a class walking by or something.

This student was aware of his (her) distractibility and made an effort each time it occurred to 'catch up' with the lesson content. S(He) knew that s(he) would miss parts of the lesson but felt s(he)'d "still be able to learn quite a lot." While s(he) was quite willing to follow teacher directions regarding question solutions, s(he) engaged in independent mathematical thought. In one instance s(he) came to the conclusion that the higher the common denominator used in addition or subtraction of fractions, the harder the work but that up to a common denominator of about 50, regardless of whether you used the lowest common denominator, the computational work would be about the same. S(He) disclosed this conclusion during the first SRI but not during the lesson.

Student DD-1-1 monitored his (her) peers as much or more than s(he) monitored the teacher during the two videotaped lessons. While the majority of these interactive thoughts which focused on his (her) peers were related to the mathematical content of the lesson, they also revealed a high degree of psychological awareness of peer behavior. S(He) exhibited a high degree of 'reflection' upon his (her) peers and their behavior as well as a high degree of 'interpretation' of teacher behaviors.

Student DD-1-2

(a) Self-concept and Mathematical Confidence

Twelve statements made by this student in the recall data (SRI-1=5, SRI-2=7) indicated personal confidence in his (her) mathematical ability. Four of these were as follows:

> "It was just half of twenty so it would work."
>
> "But I already knew."
>
> "The way I do it, I just multiply the bottom numbers together."
>
> "I already knew a shorter way."

There were five statements made by this student in the second SRI indicating confusion relative to the mathematical content of the lesson S(He) had wrong answers to some of the questions, didn't understand one of the assignment questions, had difficulty marking the previous assignment problems and initially had difficulty following student work on the overhead. In spite of these incidents s(he) managed to sort it all out to his (her) own satisfaction.

(b) Reflective Ability

Five reflections were disclosed, two relative to self-monitoring, two relative to teacher monitoring and one to peer monitoring. These reflections represented 4.8% of all this pupil's interactive thoughts in the two lessons.

(c) Introspection

Seven statements (2 + 5) revealed student awareness and monitoring of his (her) cognitive functioning. Three of these were:

> "I was quite lost."
>
> "So I just forgot about what s(he) (the teacher) was saying."
>
> "I couldn't really understand it."

(d) Perceived Locus of Control

This student exhibited an 'internal' locus of control relative to his (her) academic success in mathematics. S(He) accepted full responsibility for his (her) errors and did not attribute his (her) confusion or misunderstandings to teacher behavior. In one instance s(he) criticized a peer explanation of process. S(He) exhibited a strong 'internal' locus of control relative to classroom events in that s(he) tuned out the lesson presentation whenever s(he) felt that s(he) already understood the concept. S(He) worked at problems at his (her) desk during the two lessons. Although the teacher had not given the assignment s(he) surmised that they would be assigned and proceeded to solve the problems, stopping to monitor the lesson presentation intermittently at points which s(he) thought "might be important for another page that we do."

(e) Mathematical Verbalization

The following statements made by this student exemplify the highest level of sophistication in his (her) expression of mathematical thinking.

"So you would round it off to 30."

"He was putting it into lowest terms."

(f) Feelings

Four (1 + 3) instances of emotion experienced during the two videotaped lessons were revealed by this student. Three of these expressed boredom and one in which s(he) was 'quite glad' once s(he) discovered that s(he) had been doing the questions correctly.

The interviewee-interviewer 'initiation of dialogue' ratio was 8:4 in the first SRI and 2:9 in the second. The nodes chosen by the student focused on peers (1/8), lesson content (2/8) and him (her)self (5/8) in the first SRI and on him (her) self (2/2) in the second. While this student exhibited a high degree of mathemagenic behavior (51.2% and 47.3%) s(he) disclosed a somewhat peripheral understanding of the math concepts being taught. In the first lesson videotaped s(he) was unaware of the teacher's reason for writing the multiples in different ways, discovered a shorter method of getting solutions which s(he) described as doing it in your head and because s(he) was bored, worked on what s(he) presumed would be the assignment. During the second lesson, this student experienced difficulty at the beginning because s(he) had neglected to number the assignment questions that were being corrected, expressed boredom early in the lesson presentation, was not interested in doing a question on the overhead, and even though s(he) monitored pupil participation in the lesson presentation, chose to use his (her) own methods of finding a common denominator without grasping the significance of the use and the means of determining the lowest common denominator. S(He) also had wrong answers for a couple of questions in which s(he) had added instead of subtracted. This student found it necessary to seek help from the teacher with questions in the new assignment.

This student did not pay close attention to the total lesson presentations and consequently was unable to recall a number of classroom events. Because of his (her) confidence in his (her) mathematical ability and his (her) impatience with what s(he) considered a review, s(he) chose to work ahead independently while the lessons were in progress. Unfortunately his (her) shallow grasp of the concepts and unawareness of lesson foci are consequences not uncommon among students who deem it unnecessary to devote their full attention during math instruction, a situation which can require re-teaching but one which could be avoided through questioning techniques which confront such students with their inadequate grasp of the concepts.

Validation

The task of validating pupil recall of interactive thoughts is more difficult than the validation of teacher recall for the interviewer may still represent an 'authority figure' to the child. Although cross checks of the pupil SRI protocols for internal consistency revealed no conflicting pupil statements, pupils sometimes disclosed (prior to the interview) their desire to "do well" in the interview.

Certain interactive thoughts which they reported raised doubts in this investigator's mind about the simultaneity of the thought and the lesson event. Since there was no cognitive mismatch in any of these instances, it was impossible to confirm these doubts. These instances occurred in three SRI's where two of the students who exhibited inattentiveness during the lesson experienced some difficulty in recalling lesson events accurately. The third student who displayed accurate recall in spite of overt inattentiveness during the lesson, may have been trying to make an impression upon the investigator.

Pupil responses to interviewer interjections such as, "Do you remember (or recall) what you were thinking then?" or "Did you notice _____?" consisted of at least two instances in each SRI where the pupil response was "No.". Pupil responses to the question, "Did you understand it?" elicited mixed responses of "yes" and "no". A check was made of the number of 'leading' questions asked by the interviewer. These questions constituted less than 1.9% of the interviewer interjections. However, it may be necessary to conduct more SRI's with pupils than with teachers to assess the validity of their recall since the quantity of data collected from some pupils could be limited.

Except for student AA-2-1, the students who were interviewed made an earnest attempt to recall their interactive thoughts. They readily distinguished between their interactive and non-interactive thoughts and were meticulous in associating their interactive thoughts with specific lesson events. Most importantly, these eleven students seemed relaxed and much at ease during the course of the interview, a phenomenon indicative of the success of the familiarization phase.

Similiar Nodal Dialogue

Pupil-Pupil

Teacher-Pupil

The dialogue at similar nodes in both the teacher and pupil SRI's following the videotaping of the second lesson was analyzed for the purpose of comparing teacher and pupil perceptions of the instructional process in mathematics. These detailed analyses can be found in Appendix I . While this comparison at similar nodes underlined the wide range in pupil mathemagenic behaviors during lesson presentation and differences in learner intent, it also revealed differences in individual pupil interpretations of instructional moves, in levels of comprehension of mathematical concepts, in their abilities to monitor math content foci of lesson presentations, in the attention paid to teacher-peer dyadic interaction (particularly following pupil initiated questions), in learning dependencies upon the teacher, in potential learner confusion due to format and differences in psychological reactions to non-content related classroom events. When analyzed by individual pupil, the dialogue at similar nodes provides a comparative glimpse of unique classroom reality as preceived by students within an identical instructional environment. Certainly differences in peer proximities, seating arrangements and various ecological and human factors contribute to differences in pupil classroom life; nevertheless the idiosyncratic translation of classroom life and events into pupil reality is a covert activity seldom tapped by research techniques and a phenomenon deserving of attention for its multi-faceted potential in educational research.

The comparison of teacher and pupil dialogue at similar nodes was of particular interest to this investigator for it revealed differences between what the teacher was attempting to do and what the pupils perceived the teacher as doing. Frequently teachers disclosed that they were cognizant of the fact that they had not achieved their lesson objectives and planned to re-teach the concept, extend it, or do additional examples in a future math lesson. Of significance were instances in which the teacher was not aware of pupil misunderstanding due to the format used in mathematics instruction, of pupil mis-interpretation of instructional moves, of pupil failure to fully grasp the conceptual foci of the mathematical content of the lesson, of pupil misunderstanding due to peer illustrations of problem solutions, and of pupil failure to recognize let alone commit themselves to teacher perceived lesson objectives. The investigation of concurrent teacher and pupil thought processes during math instruction offers a viable means of identifying instructional facets which may detract from the learning process. It also provides immediate feedback on instructional effectiveness.

CHAPTER V

Summary & Discussion of Results

The purpose of this chapter is to summarize the results of the study and to relate them to the research questions. The data was collected and analyzed to answer the following questions.

1. What types of information are processed by elementary school teachers during mathematics instruction?
2. What types of information are processed by elementary school pupils during mathematics instruction?
3. Are the types of information processed by elementary school teachers related to the teacher's
    (a) beliefs about mathematics and mathematics instruction?
    (b) education in mathematics?
    (c) teaching experience?
4. How do the types of information processed by elementary school teachers during mathematics instruction compare with Marland's results?
5. Do differences exist between elementary school teacher and pupil perceptions of the mathematics instructional process?

6. Are there differences between elementary school teachers' recalled interactive thoughts when interviewed under varying foci and focal strength conditions?
7. Are there differences between elementary school teachers' recalled interactive thoughts when interviewed under constant foci and focal strength conditions?
8. What variables affect the use of stimulated recall techniques for research in teaching and learning in elementary schools?

The results relevant to each question will be presented and discussed separately.

Question 1

This question concerns the substance of the information that teachers processed during instruction. The content analysis system (SATIT) used to analyze the interactive thoughts disclosed in the stimulated recall interviews (SRI's) was exhaustive in that all of these thoughts were coded into one of the 10 categories. Eight of the 10 categories were subdivided to investigate the substantive components of each. The 10 categories and sub-categories are listed in Figure 1.

Although the focus of the second SRI's which included a semi-structured question schedule was controlled predominantly by the researcher, the microanalysis revealed clusters of thought unit categories in which the sequence of average frequencies was maintained. That is, in both the first SRI's and the second SRI's with each teacher, the sequence of average frequencies of interactive thought units recalled by the teachers were as follows:

a. Prospective Tactical Deliberations (SRI's 1 = 22.5%, SRI's 2 = 23.1%)
b. Interpretations (SRI's 1 = 14.5%, SRI's 2 = 13.0%) and Reflections (SRI's 1 - 14.2%, SRI's 2 = 13.3%)
c. Anticipations (9.1% and 10.05%) and Information - Other (9.9% and 9.9%)
d. Perceptions (7.8% and 6.2%), Information Pupil (7.5% and 8.9%) and Retrospective Tactical Deliberations (7.2% and 6.9%)
e. Goal Statements (4.9% and 4.6%)
f. Feelings (2.4% and 2.5%)

Figure 1

Summary of Categories in SATIT

1. Perceptions	Student verbal behavior, Student

	non-verbal behavior, Student work, Curriculum material, Classroom noise, Miscellaneous.
2. Interpretations	Student states of knowledge (thoughts, thought processes), Student desires (motives, needs), Student aspirations (goals), Student feelings, Miscellaneous.
3. Reflections	Student verbal behaviors, Other student behaviors, Lesson content characteristics, Classroom atmosphere (noise), Time, Miscellaneous.
4. Anticipations	What students might say (do, think, feel), Student success, Student failure (delay, confusion), Students' future needs (wants, interests), Problems likely to arise, Other classroom events likely to occur, Miscellaneous.
5. Information-Other	Curriculum content, Lesson plans, Curriculum experiences, General knowledge, Knowledge about school (community), Teaching principles (style), Beliefs about children, Routinized procedures, Miscellaneous.
6. Goal Statements	Affective, Cognitive (Pupil thoughts and understanding, Pupil attention

		and interest, Pupil work).
7.	Feelings	Anxiety or concern, Frustration (disappointment, annoyance, dissatisfaction, displeasure), Pleasure or delight, Surprise (dismay, anazement, puzzlement), Equanimity or tolerance, Feelings of disorganization, Sympathy, Foolishness.
8.	Retrospective Tactical Deliberations	Introspection, Reflection, Evaluation.
9.	Prospective Tactical Deliberations (Bases for)	Optimization of pupil learning, Pupil attention or interest, Pupil feedback, Proactive, Miscellaneous.
10.	Information-Pupil	

The greatest difference between these sequential average frequencies was between Prospective Tactical Deliberations and the cluster Interpretations and Reflections, while the remaining clusters differed by percentages ranging from 2.4% to 5%. That is, the differences in frequencies were marked enough to facilitate the rank ordering of categories and clusters of categories. Based on average percentages, the most frequent teacher interactive thoughts were deliberations about future instructional moves and the least frequent were feelings experienced during instruction. Teachers revealed a higher degree of both interpretations and reflections than perceptions although the two former stem from the latter.

Whether their perceptions were consciously or unconsciously processed, their instructional behavior was guided by their interpretations of and reflections on students behaviors and prior classroom events. That is, they actively and consistently constructed an idiosyncratic classroom reality during instruction. While all the thought units are highly interdependent, the emphasis placed on certain categories by these teachers revealed the relative importance of each for their instructional purposes. The collective average frequencies of thought units in the three categories Interpretation, Reflection and Anticipation which ranged from 37.8% to 36.3% of all interactive thoughts and which focused almost exclusively upon pupil behavior signifies the importance of realistic teacher expectations for students and accurate judgement of student states of mind.

Although a number of the teacher interactive feelings experienced may have been pervasive, the low frequency in this category reflected the absence of disciplinary problems during the eight lessons, teacher and pupil familiarity established by February, and the equanimity with which each of the four experienced teachers were able to cope with classroom realities. A comparison with Marland's results revealed that the greatest differences existed between the number of goal statements and retrospective tactical deliberations recalled by the teachers in the respective studies. Both categories in this study had relatively higher frequencies than in Marland's or in the pilot study - an indication of a higher degree of self-monitoring and proactive teaching.

Perceptions

These four teachers attended predominantly to their preceptions of student verbal and non-verbal behavior although one teacher relied considerably upon pupil facial expressions as visual cues. Except for two lessons (C-1 and C-2) which incorporated student seatwork with the lesson presentations, the videotaped lessons provided little or no opportunity to monitor teacher perceptions of student work. Significant perhaps through ommission was the limited attention given by teachers to curriculum materials used. The question raised is whether these teachers assessed them as adequate, felt unqualified to criticize or improve upon them, or neglected to even consider an evaluation of them. Not all texts and resource materials used in mathematics education are ideal and frequently communicate subtle misconceptions of what mathematics is all about. Although not empirically validated, a number of weaknesses in the curriculum materials used were obvious to this researcher. The instances of teacher and pupil miscuing revealed in the SRI data represented a very minor portion of the totality of reciprocal perceptual cuing reported.

Compared to the myriad details observed by this investigator the number of perceptions recalled by the teachers appears to be minimal. This would indicate a degree of teacher dependence upon perceptual selectivity. That is, they seemingly perceive only those aspects of classroom events which they deem relevant and screen out those deemed irrelevant thus preventing information overload. No doubt routinized procedures and classroom rules known to the pupils serve as guidelines for admissable movements, actions, and behaviors, all of which the teacher monitors through a surface awareness adequate for the purpose of detecting unusual or deviant behavior. Lessons C-1 and C-2 differed from the others in that pupil seatwork was interspersed with the lesson presentation whereas pupil seatwork followed the lesson presentation in each of the other six lessons. This would account for the higher frequency of perceptions of student work by teacher C. In lesson C-2, the teacher was implicitly aware of student verbal behavior but the recall statements were expressed as interpretations or reflections.

Teacher A used pupil facial expressions as a basis for varying the pace of the lesson, gauging pupil understanding, providing multiple embodiment, and choosing specific pupils to answer questions. In spite of considerable reliance on such visual cues, teacher A revealed a degree of skepticism regarding his (her) ability to interpret both visual and verbal pupil cues accurately in every instance. Nonetheless by combining these cues with additional confirming evidence, teacher A's sensitivity to the former constituted a facet vital to instructional expertise. Of interest was his (her) use of teacher non-verbal cues. In lesson A-1 this teacher made use of three such cues. They consisted of a gesture, "so they'll think it out", a stare "so they'd quieten down", and a touch, so "he'd get back to work".

Interpretations

Teacher interpretations of student behavior focused predominantly upon student states of mind although not to the exclusion of student affective states. It was evident that they were cognizant of the importance of student affective states for student learning. While the development of self-confidence in learning is as important as the learning itself, a difficult task for any teacher is the accurate assessment of student tolerance for those facets of the learning process which can either deter or foster the process. If teacher error is predominantly that of underestimation, individual learning potential is less likely to be attained. Ideally a non-threatening atmosphere for learning concomitantly contains a commitment to excellence which elicits maximum student effort.

The significance of these teachers' interpretations is that their subsequent actions were based on them. The redeeming feature, evident in the teachers' recalled thoughts and their observable behavior was the fact that if they erred in their judgement, the pupil(s) invariably benefited. That is, pupil understanding and empathetic moves were of primary concern to these teachers and through the use of cross checks, errors in teacher judgement of student cognitive states of mind were discovered and corrected or plans made to re-teach certain aspects of the lesson content. Student motivation for classroom work was more often revealed in case studies with reference to individual students. Where the teacher planned to re-teach certain concepts to the whole class, a question raised in this investigator's mind was what effect this repetition would have on those students who already understood the concepts.

Reflections

This category contained teacher interactive thoughts about all prior events in the lesson excluding past teacher actions. The latter were classified as Tactical Deliberations Retrospective. Teacher reflections focused predominantly on student verbal bahaviors or other behaviors. While classroom atmosphere, time, and miscellaneous factors were minor foci of some of the teachers' reflections, all four teachers reflected on lesson content to a considerable extent (Range from 10.0% to 24.0%) in each of the eight math lessons.

Anticipations

Although the teachers anticipated student success more than failure in all but one lesson, their focus was primarily on what students might think, say, do or feel. These hypotheses referred to individual students as well as groups of students. In lesson C-2, the teacher was introducing a new method of division and while s(he) was critical of the single example illustrated, his (her) initial objective and expectation was that not all of the pupils would achieve mastery of the concept within the lesson as was the case. Only three instances of a teacher comment or tactic being found humorous to students were anticipated by these teachers although one other reference to teacher intended humor occurred as a reflection.

Information Other

All teachers revealed information other than about students, which they possessed prior to the lesson. All four referred to curriculum content, curriculum experiences, teaching principles, beliefs about children and routinized procedures in their recall. These thought units were processed during instruction and collectively constituted one basis for instructional behavior.

Goal Statements

While goal statements made by the teachers were predominantly cognitive, the majority of these focused on what teachers wanted pupils to think or understand. Only two of the four teachers revealed goals for regaining or maintaining pupil attention or interest. In lesson A-2, the large percentage (42.9%) of these goals pertained to a class of students on the last day of school preceding a holiday, who according to the teacher exhibited restlessness before the lesson started. This took a good part of the lesson to overcome. Although teacher (D) did not reveal affective goals in either SRI s(he) did reveal awareness of and consideration for pupil affective needs in the recall data.

Feelings

Except for one lesson (A-2) during which the teacher felt frustrated and annoyed at pupil restlessness, the teachers experienced few emotions during the other seven videotaped. In lesson C-2, the teacher's dissatisfaction was over his (her) lesson presentation. The fact that these teachers were experienced and were videotaped under fairly structured instruction conditions may have contributed to the relatively calm atmosphere that pervaded most of the lessons, although it seemed to this investigator that these teachers consistently functioned with equanimity. They appeared to be comfortable in their roles and exhibited highly organized and purposeful behavior.

Retrospective Tactical Deliberations

This category included all teacher interactive thoughts which focused on their prior actions as well as the effects of their tactics upon pupils and pupil learning. They were sub-categorized as introspections, reflections, and evaluations. One of the teachers exhibited a high degree of introspection during instruction while all four disclosed predominantly non-evaluative reflections upon their prior instructional moves. The percentage of evaluative thought units ranged from 22.6% to 62.5% although the actual frequencies of these thoughts were relatively small in 4 of the 8 lessons. The majority of evaluative thoughts were negative indicating critical appraisal of their instructional behavior.

The higher average percentage of retrospective tactical deliberations recalled by the teachers in this study which they related to their reflections, revealed a higher degree of professional behavior monitoring, indicative of an awareness of the effects of their own actions upon pupil cognitive processes. Little or no reference was made in the protocols by the teachers to individual pupil intent or motivation to understand the mathematical concepts.

Learner intent is a subtle operant factor and a crucial determinant of academic progress, though not necessarily controllable through teacher intervention. These four teachers seemed to consciously assume almost total responsibility for pupil understanding except for infrequent references to pupil inattention and/or lack of concentration. Perhaps one of the most significant facets of this study, significant through ommission only, was a teacher focus on motivation to learn mathematics. While two teachers referred to pupil negative attitudes toward learning mathematics, few means by which pupils could be motivated to learn, like and understand mathematics as opposed to getting an acceptable mark were cited. One deterrent to fostering pupil motivation to learn mathematics is a teacher lack of relational understanding of mathematics, a condition which renders the task of making this subject cognitively appealing to others formidable if not insurmountable.

Bases for Prospective Tactical Deliberations

The bases for teacher deliberation of prospective instructional tactics were sub-categorized as (1) Optimization of pupil learning, (2) Pupil attention and interest, (3) Pupil feedback, (4) Proactive, and (5) Miscellaneous. Teacher choice of tactic was primarily based on pupil feedback, their attempts to optimize pupil learning and proactive motives. The miscellaneous bases were largely related to time or spatial factors. Teacher motives for rejecting or implementing tactics which did not relate to any of the sub-categories 1, 2, 3, or 5 were classified as proactive. The proactive bases for Prospective Tactical Deliberations revealed conscious teacher intent to control pupil participation and lesson content variables, to monitor pupil comprehension, to meet affective pupil needs, to vary the lesson pace, and to circumvent undesired consequences. The bases as sub-categorized are interdependent therefore while it might appear that pupil feedback was not a major consideration in these deliberations such a conclusion is unwarranted. For when teachers considered an alternate tactic which might optimize pupil learning, it often followed student responses which were incorrect or partially correct. These results collectively indicate that these four teachers made reasoned and deliberate choices of instructional tactics. That is, they tended to be proactive rather than reactive.

Two instances occurred where the teacher rejected a tactic because s(he) expected that the majority of students wouldn't understand the concept. Both instances presented an opportunity to extend and deepen the concept involved and for students to engage in higher levels of information processing. While only two such instances were revealed by the teachers, there seemed to this investigator, to be a host of lost opportunities for shifting the onus for information processing at medium and high levels of cognitive functioning, onto the students. Such a tactic forces the students to become active instead of passive agents in the learning process. A pervasive use of such tactics or instructional moves constitutes a strategy that enables the student to assume greater responsibility for and control over his (her) own learning. The task of the teacher then becomes one of gauging individual pupil tolerance for uncertainty and ensuring that firstly, a basic understanding is achieved and secondly that the student's cognitive skills are stretched to their limits.

Phenomena

A type of sieve coding of both the interactive and non-interactive SR data was conducted to identify larger chunks of related data which constituted a variety of phenomena. Where possible, frequency counts of evidence of each phenomenon were made.

Differential Treatment of Pupils

All teachers revealed differential treatment of individual pupils or groups of pupils based on teacher perceived pupil needs, problems or characteristics. Four principles which describe these treatments were evidenced to varying degrees in the instructional behavior of at least three of the four teachers.

(a) The Principle of Compensation whereby teachers consciously compensated for pupil traits or physical defects.

(b) The Principle of Accommodation whereby teachers modified their behavior to accommodate varying levels of pupil cognitive development or emotional maturity.

(c) The Principle of Aversion whereby teachers deliberately limited their dyadic inter-action with bright students or with those who would likely know the correct answer to a question.

(d) The Principle of Circumvention whereby teachers varied their treatment of individual pupils or groups of pupils to avoid unwanted teacher conjectured problems.

Although one basic reason for teacher tactics represented by the principle of aversion was their disclosed intent to distribute their attention fairly to all students in the class through questioning and/or individual contact, it represented a puzzling phenomenon to this investigator, for a number of rationales presented by the teachers revealed a paradoxical situation in practice. These teachers felt the necessity for accommodating and compensating for individual pupil differences but invariably tended to devote the majority of their time and attention to the seemingly disadvantaged pupils, disadvantaged academically in terms of cognitive development, personality traits, emotional maturity, and physical defects. An overwhelming and nagging impression left with this investigator of many of the lessons filmed was the existence of an intellectual void for bright and even average students in spite of the fact that infrequent high level questions were directed to a few of the brightest students in the class. In these lessons, the intellectual challenge to average students let alone bright students was largely absent, a factor directly related to teacher underestimation of pupil capabilities. This impression was substantiated in the pupil SRI's by students who came to astute and complex mathematical conclusions which were neither demanded of nor disclosed by them during the lesson. While aversion to assisting capable students with their seatwork can be partially justified, the avoidance of proportionate and appropriate teacher interaction with the brighter students cannot. Although many real and teacher perceived constraints inhibit the provision of ideal learning situations for bright students in mathematics, one obvious asset is an insightful, ingenious, resourceful mathematics teacher, one who can provide 'food for thought' to those capable of consuming it.

Constraints

One teacher cited the same number of instructional constraints (18) as did the other three collectively. Four teacher cognitive constraints and 8 pupil cognitive constructs were cited which they perceived as limiting their instructional flexibility and effectiveness.

Use of Pupils as a Gauge

These teachers disclosed that they used individual students or groups of students who were bright, average or slow for specific instructional purposes. Specific pupils were used to gauge lesson pace, class understanding, lesson content coverage, the need for explanatory tactics and to provide peer teaching. Three of the four teachers disclosed that they geered their lesson presentations to their average students.

Levels of Decision Making

The majority of the interactive decisions made by these teachers were integrative in the sense that they involved consideration of an alternative tactic, consideration of pupil feedback, or consideration of pupil needs. Teacher decisions were classified as planned (decisions made prior to instruction), interchange (decisions made during instruction resulting from teacher-pupil interaction), or unplanned (decisions made to include new or to change planned tactics or activities). For the purpose of this study, a teacher decision constituted a prospective tactical deliberation acted upon by the teacher and revealed in the recall data.

Although the unplanned decisions represented a small proportion of all decisions made, the number of interchange decisions made indicate a high degree of flexibility in instructional tactics. The modifications made were a strong indication of teacher flexibility in contingency planning of a nature designed to accommodate pupil cognitive and affective needs within the given time constraints. Although a myriad of interactive decisions are made by all teachers during the course of instruction though not necessarily consciously, the number of interactive and unplanned decisions made by these teachers and recalled in the SRI's imply an ability to cope with the unpredictable nature of classroom events, an ability requiring strong information capabilities. Further support for this contention was evidenced in the large majority of decisions, both interchange and unplanned that were integrative.

Training Effects

An examination of the non-interactive data revealed 15 instances indicative of the potential of this research technique for teacher training and development, although teacher A revealed 11 of these. Six of the training effects stemmed from teacher observations of pupil behavior observed on the videotapes, six from observations of their own behaviors and three from observations of simultaneous pupil-teacher behaviors.

One of the teacher training effects revealed during the pilot study was that of a teacher who, after viewing the first videotaped lesson, admitted during a second SRI that s(he) had made a conscious decision to ask more questions and specifically higher level questions of his brighter students. S(He) came to the conclusion that s(he) was not asking them enough questions and considered it unfair to deny them opportunities to interact simply because they knew the correct answers. One wonders whether a permanent commitment by this teacher to a fairer allotment of attention to bright students and to higher level questioning techniques was achieved as a result. Certainly the change was obvious in the second lesson videotaped.

Because of the non-evaluative stance assumed by the investigator throughout the study, the confrontation of the teacher with actual teaching behavior was non-threatening and proffered teacher self-assessments were volitional. These instances illustrated the viability of the SR technique for use in the improvement of teaching. Training programs which include an analytical design for teacher self-appraisal using videotaped lessons, might be adapted to accommodate the prospective, novice, or experienced teacher by varying the degree of external evaluation incorporated in the design. By maintaining a balanced focus of strengths and weaknesses of teaching behavior, the psychological safety of the teacher could be maintained by varying the implementation procedures to accommodate different personal levels of psychological security. Another focus for such a teacher training technique might be the examination of pupil reactions and responses to teaching behaviors. In fact the study of instructional interactions and their immediate cause and effect behavioral relationships presents a potentially fruitful source of insights into an understanding of the complex nature of the teaching process.

Many training effects were observed in the pilot study. Every teacher interviewed seized the opportunity to study and evaluate his (her) own teaching behaviors as well as pupil behaviors. In one case, the teacher's analysis of habitual pupil behavior precipitated his (her) decision during the SRI to have that pupil's hearing tested.

Heuristic Instructional Moves and Strategies

Although this investigator's interest in the use of heuristic instructional strategies is evident in the premises upon which this study was based, the research design did not provide for a definitive analysis of their occurrence in the lessons videotaped. The crude categorization of heuristic instructional moves was simply an attempt to focus attention on this area. Both Heuristic moves A and Moves B provide for increased information processing by pupils although Heuristic Moves A might be considered a higher level since they require more teacher control over learning strategies and pupil thought processes. Six Heuristic Moves A and 19 Heuristic Moves B were cited in the recall data. The majority of these moves were evident in the case study of lesson C-2 (Case Study Appendix L) and collectively constitute heuristic instructional strategies.

All of the heuristic Moves B (45) cited in the SRI protocols were made with teacher intent to force pupils to do their own thinking. Teachers used these with discretion and caution to prevent pupil reactions of fear of failure or feelings of failure. It was impossible to determine to what extent heuristic instructional moves were characteristic of individual teaching styles since only the eight SRI's and their associated videotaped lessons provided the data base for this study although numerous math lessons taught by the teachers were observed by this investigator.

Question 2

Question 2 concerns the substance of information that pupils processed during math instruction. The content analysis system of CAPIT was used to analyze the recall data from 20 SRI's with 12 pupils. This system was also exhaustive and all interactive thought units disclosed were coded into one of 11 categories. Three of the 11 categories were sub-divided to investigate the substantive components of each. The categories and their sub-categories are listed in Figure 2.

The CAPIT system identified interactive thoughts which represented pupil mathemagenic behaviors of orientation (MO) and two encoding levels (ME-I and ME-II). These three categories represented the degree to which a pupil sought to attend to and encode the mathematical content of the lesson. Three other categories of thought units MS (monitoring self), MT (monitoring teacher) and MP (monitoring peers) represented the degree to which a pupil monitored his (her) own, the teacher's and his (her) peers' behavior during instruction. These three (MS, MT, and MP) contained no explicit reference to the mathematical content of the lesson. The remaining 6 categories included pupil thoughts about information possessed prior to the lesson, (IR - those thoughts which were relevant to the lesson and II - those thoughts which were irrelevant to the lesson), thoughts about the classroom environment (EC - ecological), thoughts unrelated to lesson events or lesson content (EX - extraneous) and feelings (F) experienced during the lesson. Collectively these categories of thought units reflect the lesson content and non-lesson content monitoring behaviors of pupils during math instruction.

Average frequencies of thought units in each of the categories were compared to determine their relative occurrence. The sequential order of thought unit categories in descending order of average frequency was as follows:

Monitoring Self (MS) = 22.4%
Mathemagenic Orientation (MO) = 13.3%
Mathemagenic Encoding Level II (ME-2) = 13.1%
Monitoring Peers (MP) = 11.8%
Monitoring Teacher (MT) = 10.3%
Information Relevant (IR) = 11.3%
Mathemagenic Encoding Level I (ME-I) = 7.1%
Feelings (F) = 4.8%
Ecological (EC) = 4.3%
Information Irrelevant (II) = 1.1%
Extraneous (EX) = 1.0%

While students monitored their own behavior both overt and covert more than any other single thought unit category in CAPIT, approximately one-third of their thoughts during instruction were focused on mathematical stimuli and the encoding of mathematical stimuli. However, the individual pupil frequency of thought units in the three categories (MO, ME-I and ME-II) ranged from 14.2% to 51.2% of all interactive thoughts. When the frequency was low in these three categories, the pupil disclosed either that s(he) felt s(he) knew the concepts well enough to pursue other activities or was distracted from the lesson presentation.

Figure 2

Summary of Categories in CAPIT

1.	Mathemagenic Orientation	
2.	Mathemagenic Encoding-I	
3.	Mathemagenic Encoding-II	
4.	Monitoring-Self	Expectations, Overt actions, Reflections, Introspections, Desires.
5.	Monitoring-Teacher	Perceptions, Reflections, Interpretations, Expectations.
6.	Monitoring-Peer	Perceptions, Reflections, Interpretations, Expectations.
7.	Feelings	
8.	Information-Relevant	
9.	Information-Irrelevant	
10.	Ecological	
11.	Extraneous	

They also monitored to a considerable degree, peer and teacher behavior that was not explicitly related to lesson content and processed information they possessed prior to the lesson which was relevant to the lesson. While the behavior most often related to pupil focus on mathematical stimili or encoding of mathematical stimuli was that of the teacher, the separate category of monitoring the teacher (MT) revealed the degree to which students monitored non-lesson content related teacher behavior, interpreted or reflected upon teacher bahavior and the expectations the pupil held for future teacher behavior. The two students who exhibited a high degree of mathemagenic behaviors both seemed knowledgeable about classroom procedures and revealed a low percentage of teacher monitoring (MT) behaviors. Both of these students revealed a confidence in predicting teacher behavior and consequently, unless the teacher behavior was focused on lesson content, found it unnecessary to monitor every teacher move. One of these two pupils however revealed little interest in interpreting teacher behavior. These two students were able to create a reality out of classroom life which was congruent with their expectations and hence were able to function somewhat independently of the teacher.

Feelings experienced and information irrelevant to the lesson that was processed during instruction constituted a minor part of their interactive thoughts. In 11 of the 2 SRI's, no extraneous thoughts were revealed. Eight of these were with 4 students who revealed no extraneous thoughts in either SRI. Because of differences in category frequency patterns between different pupils and between the same pupil in two different lessons, information processing styles were examined and discussed in the section entitled "Student Profiles".

Any similarities or patterns noted in the frequency distributions of thought unit categories for individual pupils may or may not reflect consistent or typical pupil information processing styles during math instruction. In view of the different types of lessons presented, the proximity of students during the lesson and the different classroom events that occurred in each lesson, the different percentage distribution in thought unit categories for each pupil was not unexpected. This technique could be used to examine pupil information processing styles.

Mathemagenic Orientation and Mathemagenic Encoding

The students interviewed from teacher C's class exhibited higher frequencies in the three categories MO, ME-I and ME-II than did the students interviewed from each of the other three classes. However on the basis of the few students interviewed in each class and the few lessons videotaped, it was not possible to determine empirically whether this result was due to instructional factors. Two of the eight students who were interviewed twice disclosed in both SRI's, thought units in these three categories which represented more than 45% of all their interactive thoughts.

That one-third of all students' interactive thoughts focused on mathematical stimuli and the encoding of mathematical stimuli during math lesson presentations presents an interesting phenomenon, for if it is indeed representative of student mathemagenic behavior during the formal presentation of math lesson content, it could be translated into an instructional index which measures the degree to which a teacher is able to engage pupils in mathematical information processing. On this basis the math instructional index for each of the 4 teachers in this study over two lessons would be as follows:

Teacher A = .3118

Teacher B = .239

Teacher C = .416

Teacher D - .345

These indexes of course are not comparable or even interpretable since the number of pupils interviewed per teacher ranged from 4 to 7, the number of pupils and lessons were too few and the instructional contexts too dissimiliar. However, such an index, if properly determined might yield a teaching effectiveness indicator which is likely to be more valid than one based on observed overt pupil behaviors. Since such an index does not measure the level of pupil information processing induced by a teacher, a further refinement of the content analysis system would be necessary to qualitatively identify pupil encoding and decoding skills in terms of differentiated semantic frames.

Monitoring Self

While all students monitored their own behaviors to a high degree, the *average* frequency of introspections *and* reflections constituted 41.5% of all their self-monitoring thought units. These thoughts indicate an ability to monitor their own thought processes and to reflect upon their past actions. Although expectations and desires were revealed, they were not examined relative to their fulfillment.

Although quantitative comparisons can be useful, the qualitative analysis of thought units in the sub-categories of 'reflections' and 'expectations' yields greater insight into the pupil's classroom life. Expectations and desires could be examined in light of their subsequent fulfillments and realizations. This study was not designed to this end. The macro-analysis of these sub-categories was conducted to examine aspects of these thought units for the purpose of identifying emergent phenomena.

While all students monitored their own overt behaviors to a high degree, the degree of individual reflection and introspection was of special interest to this investigator. Together they reveal early attempts to monitor cognitive functioning and to reflect upon past actions as a basis for future decisions and behaviors. They represent a phenomenon indicative of the uniquely human aspiration and sometimes capacity to achieve mastery over one's own destiny. More significant perhaps than percentage distribution is the total number of such thought units revealed by each pupil.

Monitoring Teacher

The students reflected upon teacher behavior observed during instruction and to a minor degree anticipated future teacher actions. These students interpreted teacher behavior to a high degree (Average % = 44.4). In fact the total frequency of these interpretations represented 4.57% (Average Frequency) of all pupil interactive thoughts. More significant than their content is their mesh with reality although this study was not designed to investigate this aspect.

Pupil interpretive skills combined with communication skills can enhance or hinder the congruency between pupil reality and teacher reality in classroom life. These reflections, expectations and interpretations constitute factors which influence learner receptivity to instructional stimuli.

Monitoring Peers

Students monitored their peers even though that peer behavior had no mathematical content focus. In five SRI's, the pupil interviewed revealed a low percentage of interactive thoughts in this category. Students tended to monitor the overt behavior of their peers more than they interpreted or reflected upon peer behavior during the lesson. The student who exhibited the least focus on peers (BB-1-1) disclosed no interpretive thoughts of peer behavior.

Feelings

Relatively few feelings experienced during instruction were disclosed by students although one student (AA-1-2) revealed a 'consistent' high frequency in each of the two SRI's. Another student (A[illegible]2-3) who was interviewed once, disclosed the highest frequency (13.2%) of thought units in this category. This student revealed feelings of anxiety dur the lesson relative to the mathematical content of the lesson.

While the student stimulated recall protocols tended to be much shorter in length particularly for those in the lowest grade level (4), five of these contained more interactive thought units than two of the teacher stimulated recall protocols. The wide variations in the frequency of student recalled thought units were not solely related to grade level. One student in grade 6 revealed two of the lowest frequencies while one student in grade 4 revealed the highest frequency of all students interviewed. The quantity of pupil interactive thoughts disclosed appeared to be a function of personality traits and verbal behavior patterns. The pupils generally had more difficulty than the teachers in recalling specific details of the lesson and sequences of details.

Phenomena

A macro-analysis of both interactive and non-interactive thoughts revealed in the pupil SRI's was conducted. The recall data was sieve coded for evidence of the following five phenomena.

Self-concept and Mathematical Confidence
Reflective Ability
Introspective Ability
Pupil Perceived Locus of Control
Mathematical Verbalization

Since this study was not explicitly designed to elicit pupil recall which focused on these phenomena, the results as presented in the student profiles cannot establish individual information processing styles. They merely provide a glimpse of those facets of classroom life which constitute each pupil's construction of classroom reality. Table 22 presents an analysis of each pupil profile.

These student profiles, which were based on two math lessons, indicate the potential of stimulated recall techniques for diagnostic purposes. Longitudinal studies might reveal unique pupil information processing styles. Perhaps the most fruitful application of such research data might be the analysis of levels of pupil information processing resulting from heuristic instructional strategies in which semantic frames of varying levels are employed.

Question 3

This question concerns the relationship between the types of information processed by elementary school teachers and their

(a) Beliefs about Mathematics and Mathematics Instruction

(b) Education in Mathematics and

(c) Teaching Experience

Table 22

Analysis of Pupil Profiles

Student	Grade	No. of SRI's	Number of thoughts revealing self-concept and mathematical confidence		Reflections as a percentage of all pupil interactive thoughts	Number of introspections revealed	Pupil perceived locus of control relative to academic success	Classroom events	Number of interactive feelings revealed
			Positive	Negative					
AA-1-1	4	1	7	0	6.6%	3	Internal	Internal	3
AA-1-2	5	2	27	4	9.8%	5	Internal	External	20
AA-2-3	5	1	8	3	7.4%	4	Internal	Internal	9
BB-1-1	6	2	37	3	5.8%	48	Internal	Internal	23
BB-1-2	6	2	25	4	11.8%	10	Internal	External	10
CC-1-1	4	1	5	3	9.6%	1	Internal	Internal	2
CC-1-2	4	2	23	0	11.6%	4	Internal	Internal	6
CC-1-3	4	2	7	9	15.8%	8	Internal	External	9
CC-1-4	4	2	23	3	9.5%	5	Internal	Internal	9
DD-1-1	5	2	13	4	9.8%	11	Internal	External	5
DD-1-2	5	2	12	5	4.8%	7	Internal	Internal	4

All four teachers scored relatively close to a neutral dimension on the informal-formal continumn on both the BAMS and BAMIS instruments, all had taught for either 6 or 10 years and none had specialized in mathematics during professional training. Although these similarities may have precluded any answer to the question, the non-qualitative basis of the SATIT system prevented any attempt to relate the variables to the types of information processed by teachers during math instruction. An examination of the teacher thought units in the categories of tactical deliberations prospective and retrospective and of goal statements revealed qualitative differences which were obscured in a purely quantitative analysis. Although the frequency patterns of categories of information processed by the four teachers during math instruction were similar, a few differences were noted. Teacher C tended to process fewer perceptions and more information-other than did the other three teachers. Teacher A tended to interpret pupil behavior more and engaged in prospective tactical deliberations less that the other three teachers. An examination of the implicit theories held by these teachers which were revealed in the SRI's provides an insight into the principles and beliefs upon which much of their instructional behavior was based. Although the collection of more recall data over a longer period of time is necessary to attempt an analysis of teacher information processing styles, qualitative analysis of such data gathered from teachers with different amounts of math education and years of teaching experience would facilitate the answering of this question. Furthermore, the development of an instrument which could measure the informal-formal dimension of actual teacher behavior during math instruction or one that measures teacher ability to raise levels of pupil information processing during instruction could make the use of such instruments as BAMS and BAMIS more fruitful for both teacher self-evaluation and for teacher training purposes. Such an instrument could also be made subject specific.

Although these instruments were designed to determine the extent to which teachers focus on the creative and investigative nature of mathematics (informal) as opposed to the formal content of mathematics, Collier (1972) expressed some concern about the sensitivity of the instruments. He also found that his scores (of 264 subjects) tended to fall in the neutral range. He noted two factors which could limit the range of beliefs found in his sample, namely ,

1) That the beliefs of the students were formed over many years and hence would not change radically over a short period of time,

and 2) The students tested had not been exposed to courses which had formation of beliefs as a specific course objective. The latter factor is one worth considering further if the premise that instructional behavior reflects beliefs about mathematics, is valid.

A further limitation of the instruments is their generality. As in most testing instruments, the specificity of the bases upon which the items are interpreted can affect the responses made. This was evident in two out of the four teachers' returns in this study.

Further use of these instruments might be more rewarding if they were linked to the characteristics of the students in the referent class. An obvious problem to be overcome would be an accurate determination of those pupil characteristics deemed by the teacher to be relevant to their use or non-use of informal instructional methods.

Question 4

This question deals with the results from Marland's study (1977) and the recall data from the first SRI conducted with each of the four teachers in this study. Because the second SRI's in this study involved a stronger focus on different facets of instruction set predominantly by the researcher, only the data in which the focus and focal strength were similar was compared with Marland's results. Since there were many similarities between the results of the two studies, only the differences will be discussed.

The two categories Retrospective Tactical Deliberations and Goal Statements contained relatively higher frequencies than in Marland's study (or the pilot study) where the only identifiable difference in teacher presage variables was that all the teachers in this study had at least 6 years of teaching experience whereas the teaching experience varied from 16 to 0.2 years in Marland's study. The frequency of RTD thought units in this study was significant in that given the plethora of interactive events and teacher decision-making required during the lesson presentation teachers might be more apt to engage in an analysis and evaluation of their instructional tactics after instruction rather than during. It also attests to their immediate monitoring of the effects of instructional moves on pupils and pupil learning which formed the bases for changes in tactics during the lesson and for planning instruction in subsequent lessons. The goal statements revealed by the four teachers in this study were more specific than the lesson goals disclosed by them in the pre-active interviews and were frequently related to individual students. The frequency of these goal statements attests to the relatively strong guidelines upon which instructional behavior was based.

A difference was noted in Marland's study between the frequency of Prospective Tactical Deliberations in math lessons (Average frequency = 22.4%) and language arts lessons (Average frequency = 16%) revealed by four of the six teachers. This high frequency of PTD was also revealed by the four teachers in this study (22.5%). In both studies the highest average frequency of interactive thought units was prospective tactical deliberations.

A difference was also noted in the number of feelings disclosed by the teachers. Emotions experienced by teachers in Marland's study constituted 5.6% (Average frequency) of their thoughts during instruction while those experienced by the four teachers in the study constituted 2.4% (Average frequency). Unlike Marland's results, these four teachers gave no indication either verbally in the SRI's or behaviorally during instruction that they were suppressing their emotions. Teacher A disclosed that in a non-research situation similar class behavior would not elicit any different reactions on **his** (her) part.

Another difference noted was in the focus of teacher interpretations. The teachers in this study interpreted student states of mind and thought processes twice as often as did the teachers in Marland's study and student feelings one-half as often as those in Marland's study. These differences were based on average frequencies.

Of the five teaching principles cited by Marland as exerting a pervasive influence on teaching behavior, only one was evident in this study. The Principle of Compensation was employed by teachers in both studies although Marland's definition of this principle encompassed the Principle of Accommodation as it was defined and observed in this study.

The differences cited between the results of the two studies may or may not be significant. An assessment of these differences would require research under laboratory conditions in which more variables could be controlled.

Question 5

To determine whether differences exist between elementary school teacher and pupil perceptions of the instructional process in mathematics, the dialogue at similiar nodes in the second SRI's with both pupils and teachers was analyzed and compared. Since the differences in pupil perceptions have been discussed (Appendix I), this question focuses on differences between teacher and pupil perceptions of the instructional process. There were twenty differences revealed by the teacher and one or more pupils in the SRI's following the videotaping of the four lessons (A-2, B-2, C-2, and D-2). These perceptual differences were of instructional moves which were related to (1) lesson organization, (2) lesson content and (3) teacher-pupil interaction.

Lesson Organization (2): In lesson A-2 the teacher's remark "Quickly now" was interpreted by one student (AA-2-3) as an indication of the concept level of difficulty whereas the teacher's intent was to get the students to put their worksheets away and get ready for the lesson presentation. While an unexpected scheduling of 'snack time' elicited different reactions from students AA-2-2 and AA-2-3 (the former was upset and the latter relieved), the changes in lesson plans, the assignment of a server, and the monitoring of time to provide for ten minutes at the end of the lesson to eat the snacks collectively added to the teacher information processing load and constituted several deterrents to achieving the lesson objectives.

Lesson Content (10): The greatest number of differences revealed were related to the lesson content itself. The significance of two major concepts in lesson A-2 was perceived differently by the teacher and the two students interviewed. One concept involved a student proffered method of adding decimals and the other a difference in the need for adding zeros as place holders in the subtraction of decimals as opposed to the addition of decimals. The former caused some student misunderstanding while the latter was not cited by either student in the SRI's. While the content of the lesson at this point provided an opportune time to discuss the legitimacy of deleting or adding zeros to specific kinds of numbers, it was not pursued. In lesson B-2, these differences in pupil and teacher perceptions involved the teacher's introductory use of a specific fraction and two instances where the format of the lesson content caused pupil misunderstanding of which the teacher was unaware. The four instances in lesson C-2 related to pupil misinterpretation of teacher intent to increase their understanding of related mathematical concepts. Only one of the three students interviewed revealed an insightful valid conception of the teacher's lesson objectives. One instance in lesson D-2 revealed that the two interviewed pupils' perceptions of lesson concept defeated the purpose of the teacher's instructional move.

Teacher-pupil Interaction (8): Of these eight differences, one involved an instructional move to elicit pupil questions, one to provide teacher feedback to a student initiated question, four involved teacher questioning strategies and two involved pupil responses to teacher initiated questions. The recall data revealed that pupils were not always aware of the teacher's motives underlying questioning techniques and feedback.

and in other cases pupils misinterpreted teacher motives. While an awareness may not be a prerequisite for pupil learning, incorrect pupil interpretation of teacher motives may constitute a deterrent to learning. The data also revealed that pupils did not necessarily attend to teacher-peer dyadic interaction even when it was focused on lesson content. Poorly phrased pupil questions, poor pupil diction and inaudible pupil responses were pupil cited reasons why they did not monitor certain teacher-peer interactions.

Summary

A comparison of teacher and pupil perceptions of the mathematics instructional process revealed that

(1) pupils perceived lesson objectives differently than the teacher,

(2) pupils perceived mathematical content format differently than the teacher,

(3) teacher motives underlying instructional moves were incongruent with pupil perception of those motives,

(4) pupils were selective in their monitoring of teacher-pupil dyadic verbal interaction during lesson presentation.

Since it is unlikely that pupil and teacher perceptions of the instructional process would ever be totally congruent, only those differences which might influence the learning process were relevant to this study. Pupil misunderstanding due to format in math instruction may constitute a learning deterrent of which teachers are not cognizant. Teacher-pupil interaction focused on lesson content which is not monitored by peers during lesson presentations constitutes valuable lesson time which could be used to better advantage. Pupil and/or teacher imprecision in the verbalization of mathematical thinking introduces distractors to the learning process. Teacher unawareness of student affective reactions to peer behavior and classroom events omits an important basis for modifying instructional tactics.

Of particular interest to this investigator were the differences revealed in the SRI's between the pupils' perceptions of what they were being taught and what the teacher intended to teach. In some instances, pupils interpreted lesson presentations as reviews of content they had already been taught whereas the teacher perceived the content as representing significant points of transition from one concept to another or as important conceptual relationships basic to the transference of known skills. Nor were all students interviewed able to identify the salient and important expansions of concepts to higher levels of comprehension. That is, the essence of the teacher's instructional intent was not fully grasped. Students professed boredom at various stages in lesson presentations yet they failed to understand the concept well enough to identify what the teacher was attempting to do even though they were monitoring the presentation. Those who disclosed that nothing new had been taught were sometimes unable to identify the major or minor conceptual foci of the lesson presentation. If their objective was to learn something new in the content topic, they failed to even identify it as new. Pupils also revealed their lack of understanding regarding the purpose and significance of certain teacher illustrations yet they did not question it covertly or overtly during the lesson. While the aforementioned has implications for instructional methodology, learner motivation and information processing capacities, one conclusion emerges: Pupils are not always cognizant of teacher perceived lesson objectives.

Question 6

This question deals with differences between elementary school teachers' recalled interactive thoughts when interviewed under varying foci and focal strength conditions. While the lessons videotaped were similar in that they consisted of teacher introductory presentations of a new concept in the first lesson and of teacher presentations of a lesson based on the same content unit a few days later, no attempt was made to control instructional variables. In the first SRI with each teacher, the focus was determined predominantly by the teacher and the focal strength moderate. In the second SRI, the focus was determined predominantly by the interviewer and the focus strengthened through the use of a semi-structured question schedule.

On the basis of teacher selected nodes, the predominant focus of all four teachers in the first SRI's was on their instructional moves. In the second SRI's this focus was maintained by teachers A and C but not by teachers B and D. The latter two teachers focused primarily on pupil behavior. Based on the SATIT categories used in the analysis of teacher recalled interactive thoughts, a number of differences were noted. Teachers B and D each disclosed a higher percentage of perceptions during the second SRI indicating a higher degree of monitoring of overt pupil behavior. Both teachers B and D recalled a lower percentage of retrospective tactical deliberations in the second SRI. Teacher B disclosed more than twice the percentage of interpretations in the second lesson as in the first and a much lower percentage of prospective tactical deliberations in the second lesson. Teacher D recalled a higher percentage of TDP and a lower percentage of anticipations in the second lesson than in the first. Teacher C recalled a higher percentage of reflections in the second lesson than in the first. Teacher A retained the most stable distribution of thoughts over all categories in the first and second SRI's. All but teacher D recalled a lower percentage of information about pupils in the second SRI and all but teacher B recalled a lower percentage of 'Information Other' in the second SRI. All but teacher A revealed a slightly higher percentage of goal statements in the second SRI.

For teachers B and D, the higher percentage of thoughts focused on perceptions (predominantly of pupil behavior) and their focus on pupil behavior in teacher selected nodes would seem to indicate that pupil behavior dominated their interactive thoughts leaving less capacity to process other kinds of information. It was impossible to determine empirically whether this difference was due to the change in the SRI focus and focal strength or to differences in pupil behavior during the second lesson although the latter seemed to be the more predominating factor. In view of the relatively stable foci of interactive thoughts recalled by teachers A and C and the differences in pupil behavior observed during lessons B-2 and D-2, it may well be possible to examine teacher information processing styles based on interviewer selection of nodes and the use of interview question schedules. Such an approach would enable the researcher to pursue a particular focus of inquiry as well as ascertain teacher information processing styles. However further research under laboratory conditions would be necessary to confirm the viability of such a research design.

Question 7

This question deals with differences between elementary school teachers' recalled interactive thoughts when interviewed under constant foci and focal strength conditions. The differences revealed through this comparison were greater than those where foci and focal strength were varied. While these differences would constitute a basis for comparing individual teacher information processing styles, the small number of lessons videotaped and the large number of uncontrolled instructional variables prohibit any valid assessment. A number of comparisons could be made on the basis of these teachers' percentage distributions of interactive thoughts over SATIT categories but since this content analysis system was solely quantitative within the categories, the implications of these comparisons could well be misleading. For in this system teacher deliberations over which pupil to question are equated to teacher deliberations over alternate tactics for achieving a greater depth of pupil conceptual understanding. Any attempt to determine teacher information processing styles as an indicator of effective teaching would require a definitive content analysis system in which teacher interactive thoughts are both qualitatively and quantitatively categorized and analyzed.

Question 8

This question examines the variables affecting the use of stimulated recall techniques for research on teaching and learning in elementary schools. As a research technique, stimulated recall (SR) offers a potentially powerful tool for analysis; however the technique is both fragile and time-consuming. It's viability is highly contingent upon the integrity, sensitivity and perceptiveness of both the interviewee and the interviewer. It's success is dependent upon a carefully established rapport between researcher and subject which must include mutual trust and respect. In spite of a carefully planned familiarization phase, interviewees may through reticence and /or inability fail to voluntarily disclose their interactive thoughts and feelings. Several variables affecting the use of this technique include the following:

(1)	Researcher training:	To achieve the necessary skills for collecting and analyzing the data.
(2)	Volunteer subjects:	Teachers and pupils who are willing to commit themselves to the time and effort re-

quired by this technique.

(3) Audio-visual equipment: Sophisticated enough to capture the audio and visual components of instruction.

(4) Selection of pupils: Age, verbal skills and personality of the subject have to be considered.

(5) Preservation of a naturalistic setting: A familiarization phase is required.

(6) Scope of the research study: The collection of sufficient data upon which to base conclusions may require a long-term research project.

The investigation of teacher or pupil thought processes during instruction in natural settings does require a familiarization phase to minimize the degree of distraction caused by the presence of the technical equipment and the researcher. The duration of this phase may vary with each class. In schools where teachers and students were familiar with cameras and videotape recorders (as occurred in the pilot study) a week is sufficient. However, in the research study the week of familiarization was not as successful in overcoming the intrusive effects of the research activities upon several students who were interviewed. Teachers generally were oblivious to the camera during the videotaping of the lessons. They indicated in some cases, an initial awareness of the camera in the classroom but quickly became totally absorbed in the lesson.

Except for one student (DD-1-1), those students who were interviewed twice generally revealed a decrease in their awareness of the videotaping as well as a change from a personal to an impersonal interest in the camera. Since they had been shown videotaped excerpts of their previous lessons during the familiarization phase, perhaps it took one lesson which they did not view to convince them that the research videotaped would not be shown in class. Certainly the presence of the VTR equipment constituted an ecological factor which would not likely ever be totally ignored by the students, particularly students who were apt to be chosen for the subsequent SRI's. However, further research is needed to assess the degree to which videotaping influences pupil behavior during instruction. Student BB-1-2 did feel self-conscious at one point during the first lesson and altered his (her) behavior because of the videotaping. A future design might include a testing phase for students before the research data collection is initiated.

It may be impossible to ascertain the focus of teacher information processing during instruction using a strong research focus and a high number of interviewer selected nodes. The latter however, can reveal teacher thoughts during those events which the researcher deems 'critical'. That is, the technique of SR is flexible. A further study might investigate teacher information processing using nodes chosen exclusively by the researcher.

In spite of its drawbacks, this technique does provide a unique tool for research on teaching and learning in elementary schools. It constitutes a viable approach to examining the simultaneous cognitive processes of teachers and pupils during instruction, one which probes for subtle factors pervading the instructional process. Combined with observations of overt teacher and pupil behavior, it constitutes a diagnostic approach to instructional effectiveness which does not exclude teacher and learner intent. While the maximal potential of this technique may well be realized through the exploration and analysis of simultaneous teacher and pupil information processing during instruction, preemptory conclusions based on insufficient or non-discrete data constitutes a hazard in a design which attempts to combine an analysis of information processing styles with that of comparative simultaneous information processing by teachers and pupils.

CHAPTER VI

Conclusions, Implications and Recommendations

Conclusions

The purpose of this study was to investigate the types of information processed by teachers and pupils during math instruction, to compare their perceptions of the instructional process, and to explore the potentialities of stimulated recall techniques for research on teaching and learning in elementary schools. Since the sample of teachers and of pupils was small (only two lessons per teacher were videotaped and at most two SRI's per subject conducted) the following conclusions must be regarded as tentative.

1. Analysis of teacher thoughts during math instruction revealed that while they processed the same kinds of information in varying amounts,
    (a) they all considered future instructional tactics to a considerable degree (approximately 20 to 25% of all their interactive thoughts) and reflected on their past instructional behavior to some degree (5 to 9%) of all their interactive thoughts). These retrospective tactical deliberations included assessments

of the effects of their instructional behavior upon pupils and pupil learning which were predominantly critical.

(b) an analysis of their perceptions revealed that they attended predominantly to student verbal and non-verbal behaviors.

(c) more than a third of all their interactive thoughts consisted of interpretations, reflections, and anticipations which focused primarily on pupil behavior indicating a high reliance upon pupil feedback and teacher estimates of student states of mind.

(d) all teachers disclosed instructional goals of which they were cognizant during the lesson. These goals were predominantly cognitive and more specific than the goals revealed in the pre-active interviews.

(e) an analysis of the factors considered by teachers in their deliberations about future instructional moves indicated that all four teachers were proactive rather than reactive. All teachers attempted to optimize pupil learning through specific instructional moves although teacher C disclosed the highest frequency of such bases.

(f) phenomena identified in the recall data included the following:

i. teachers revealed deliberate differential treatment of pupils which the following principles describe:

  (1) The Principle of Compensation.
  (2) The Principle of Accommodation.
  (3) The Principle of Aversion.
  (4) The Principle of Circumvention.

ii. the teachers disclosed teacher cognitive and pupil cognitive constraints which they perceived as limiting their instructional flexibility and effectiveness.

iii. all teachers revealed a reliance on specific pupils for feedback upon which to gauge lesson pace, content coverage, class understanding of concepts or the need for modification tactics.

iv. the number of teacher decisions made during instruction resulting from teacher-pupil interactions indicated a high degree of flexibility in coping with the unpredictable nature of instructional situations. While the small proportion of decisions made to include new or alter planned instructional tactics did not differ radically from their pre-instructional plans, invariably such decisions were made to eradicate pupil misunderstandings or to facilitate increased understanding of mathematical concepts.

v. an analysis of the non-interactive data revealed 15 training effects indicative of the potential of this technique for teacher training and development.

vi. heuristic instructional moves which attempted either to guide pupil thought processes or to increase pupil information processing were identified in the recall data. These moves fostered teacher-independent pupil cognitive processes.

2. Analysis of pupil thoughts during math instruction revealed that

   (a) pupils differed widely in the degree to which they engaged in mathemagenic behaviors during lesson presentations (14.2% to 51.2%).

   (b) all students interviewed were self-monitoring in that they were cognizant of their overt and covert behavior but in varying degrees. Three students who revealed comprehensive understanding of the lesson content disclosed the highest percentage frequencies of self-monitoring thoughts.

(c) the students interpreted teacher behavior to a high degree although their individual interpretations of identical teacher behavior frequently differed.

(d) during instruction, these students tended to monitor the overt behavior of their peers more than they interpreted or reflected upon peer behavior.

(e) phenomena identified in the recall data and presented as student profiles revealed many differences among pupils when compared both descriptively and quantitatively on the basis of

   i. positive and negative thoughts relative to pupil self-concept and mathematical confidence,
   ii. pupil introspections during instruction,
   iii. feelings experienced during instruction,
   iv. pupil perceived 'locus of control' relative to their own academic success in math or to classroom events, and
   v. reflective ability.

3. No evidence was found in the results of the study which could establish a relationship between the

types of information processed by teachers and their education in mathematics, teaching experience or teacher beliefs about mathematics and mathematics instruction.

(4) A comparison of partial results of this study with those of Marland's (1977) revealed differences in the average percentage frequencies of 'retrospective tactical deliberations' and 'goal statements' which were higher than in Marland's study and 'feelings' which were lower than in Marland's study. A similar high average percentage frequency of 'prospective tactical deliberations' during math instruction was revealed in both studies.

(5) Analysis of SRI dialogue at similar nodes revealed differences in teacher and pupil perceptions of the instructional process in mathematics. Instructional moves related to lesson organization, lesson content and teacher-pupil interaction were perceived differently by the teacher and one or more interviewed students. Evidence of the following differences were found:

(a) pupils perceived lesson objectives differently than the teacher,

(b) pupils perceived mathematical format differently than the teacher,

(c) teacher motives underlying instructional moves were incongruent with pupil perceptions of those motives,

(d) pupils differed in their selective monitoring of teacher-peer verbal interaction during lesson presentations, and

(e) incongruencies existed between what the teacher intended to teach, actually taught and what the pupils perceived as having been taught. These incongruencies were consistent in that what the teacher intended to teach fell short of what was actually taught which was less than what the pupils perceived as having been taught.

6. A research design which would enable an investigator to pursue a specific area of inquiry and simultaneously examine information processing styles could enhance the future use of the stimulated recall technique in research on teaching and learning. The results of this study seem to support such a research design but further research is needed to confirm this hypothesis.

7. The results of this study seem to indicate that an

attempt to determine information processing styles of teachers on the basis of comparative percentage frequencies of teacher recalled interactive thoughts would require a qualitative microanalysis of the data since a purely quantitative analysis might well be superficial. Longitudinal studies are necessary to determine either teacher or pupil information processing styles.

8. Due attention to the variables influencing the efficiency of this technique, refined data reduction systems and carefully conceptualized research designs collectively could increase the potential of stimulated recall techniques in research on teaching and learning.

Implications and Recommendations

The results of this study have a number of general implications and several specific implications for research and teacher education.

Specific Implications

As one of a few research studies on the covert mental activity of teachers during instruction and perhaps a first on the covert mental activity of pupils during instruction, this study offers evidence that the use of introspective methods and the concept of teacher or pupil as information processor has potential for providing insights into teaching and learning. More importantly, when simultaneous thought processes of teacher and pupils during instruction are examined the impact of instruction upon learning is revealed. The richness of the data and the exploratory nature of the study have unveiled a host of prospective research directions.

Research

A. Due to the relatively new use of introspective methods in research on teaching and learning a number of methodological facets need to be examined and refined.

   1. There is a need to refine the data reduction systems of analysis since both qualitative and quantitative analyses are needed to capture maximal insights from the rich data.

   2. Technological refinements are needed to capture both teacher and pupil verbal behavior during instruction as well as content format and the use of graphics in math instruction.

3. There is a need to establish concurrent validity through the simultaneous use of a variety of research techniques including ethnographic studies.

4. Modifications of the familiarization phase and interview techniques are needed to determine the viability of using stimulated recall techniques as a diagnostic tool with pupils who are low achievers in mathematics.

5. There is a need to explore the use of different interviewer question schedules in stimulated recall interviews for determining either teacher or pupil understanding of mathematics.

6. The development of a system for analyzing heuristic teaching at a modular level in mathematics would facilitate the investigation of instructional effectiveness when combined with introspective techniques and pupil product measures.

B. Areas of research which could be pursued include the following:

   1. Use of these same techniques in laboratory settings where specific variables can be controlled.

2. Longitudinal studies to investigate teacher or pupil information processing styles.

3. Correlational studies to determine the relationship between information processing styles of 'master' teachers and novice teachers.

4. Pedagogical studies which make use of introspective techniques to examine the relationship between teacher understanding of mathematics, teacher objectives in math education and interactive decision making.

5. Longitudinal studies which examine pupil and teacher perceptions of the instructional process in mathematics and their respective awareness of lesson objectives.

6. Exploratory studies to assess the relationship between lesson pace, levels of questioning and the quality of information processing by pupils during instruction.

7. Studies which identify relevant phenomena in math instruction which correlate with product measures.

8. Further studies of teacher and pupil concurrent thought processes during math instruction.

9. Research techniques for 'time on task' studies could be used in conjunction with stimulated recall techniques to monitor pupil interactive information processing during pre-determined time frames.

Teacher Education

The results of this study indicate that information processing capacities and styles of both teachers and pupils are related to instructional and learning behavior. As a training technique, stimulated recall offers one means of relating instructional behavior to teacher information processing. When used to examine concurrent teacher and pupil information processing, it provides an immediate assessment of instructional effectiveness. The results of this study suggest that

(1) data from studies on teacher and pupil information processing during instruction could become part of teacher training curricula and that

(2) stimulated recall could be used as a diagnostic

tool in teacher training to

a. improve interactive decision making,

b. increase teacher self-monitoring,

c. facilitate identification and correct interpretation of a variety of student 'cues'

d. improve teacher estimates of student states of mind,

e. analyze teaching behaviors,

f. assess the effectiveness of instructional strategies and to

g. disclose the relationship between teacher expectations, instructional behavior and levels of pupil information processing.

General Implications

Two of the major problems to be solved in this type of research are the ethical and legal implications embedded in the professional commitment to subject anonymity. To retain open access to research sources, such commitments may be necessary but at the same time entail forfeiture of valuable research data by research institutes and/or faculties of education. In the event that such a commitment can be waived with the consent of participant subjects, future use of the research data necessitates a careful delineation of the legalities involved.

In view of the time and money expended on such research, an examination of its most productive potential is essential. Because of unsolved problems relative to validity, this technique might best be used in conjunction with one or more different techniques where at least concurrent validity is assured.

Because of the extensive training required by those who engage in such research and the caution which must be exercised in drawing conclusions or attempting to make generalizations on the basis of data collected, it behooves the research sponsoring agency both for its own benefit and in the interest of long-term research projects to retain researchers who are skilled in this technique. While graduate students might constitute an available pool of research personnel, sole reliance on such expertise does not enhance the fruition or continuity of this type of research to the same degree.

Notwithstanding the valuable contributions to math education by past and present research, math education is and will remain in dire straits unless research which focuses on basic causes of unrealized mathematical potential is relentlessly pursued. Many students in our elementary school classrooms are already exhibiting aversions to understanding math and rapidly losing confidence in their abilities to handle mathematical situations. To attempt a cure for mathophobia or math anxiety at the senior high, college or university level is to magnify the task whereas prevention at the elementary school level is potentially more realistic. We must find out why students lose interest in math and what instructional facets cause students to lose trust in their own mathematical judgement, since in our society, to turn one's back on mathematics is to close too many vocational and professional doors.

Those who decry the limited 'pay-off' from educational research may find that the contributions required in cooperative research of this nature are more than they are willing or able to offer. But those who believe in the efficacy of fundamental research may see the need for repriorizing the assignation of research funds lest we reach the stage in our educational system when survival becomes more important than purpose.

Those who rely on statistical results of student computational skill tests as an indicator of mathematical proficiency, must realize that the use of a host of computational devices in our technological society has rendered such measures archaic. Under pressure from a general public which mistakenly lobbies for a 'back to the basics' (not as defined by NCTM) math curriculum any government which yields to that pressure and implements such a simplistic curriculum can effect a massive set-back in mathematics education. Now, in fact, we are finally in a position to eliminate the instrumental approach to mathematical understanding and in its place implement a math education curriculum which communicates to learners a relational understanding which renders it functional and transferable.

Given the cut-backs (relative to inflationary costs) in public education funding and the deletion of specialists and consultants in elementary schools and school districts, how many school districts retain elementary school math consultants let alone provide for professional development or re-training of these? How knowledgeable are these math consultants about the future mathematical needs of our citizens in the year 2000? Do our high school counsellors know that mathematics is now more than ever, the academic sieve for entrance into university faculties?

While the foregoing attests to the urgent need for increased research in the field of math education, it behooves us as educators and researchers to re-examine what we mean by 'mathematics'!

The technique of stimulated recall could be used in research, teacher training or professional development. It is a useful tool for self-analysis of teaching behavior when based on a self-initiated commitment to improved instruction. It could be used to study the mental life of students during instruction, and to probe for factors inhibitory to learning such as information processing limitations, lack of learning strategies or instructional weaknesses.

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APPENDIX A

PREACTIVE INTERVIEW

PREACTIVE INTERVIEW

Each teacher participating in the research project will be videotaped on two occasions each of approximately forty minutes duration. A preactive interview is to be conducted with the teacher prior to each videotaping session. The preactive interview consists of two parts. The purpose of Part A is to have the teacher indicate the goals of the lesson to be taught during the vdieotaped session. The purpose of Part B is to have the teacher indicate the plans s(he) has made for achieving the lesson goals.

Conduct of the Interview

The purpose of the interview is to have the teacher reveal the nature of the actual lesson plan, written and/or unwritten, that s(he) has developed prior to instruction. The role of the interviewer is to facilitate a full disclosure by the teacher of details of the lesson plan without omission, addition, or distortion. It is imperative that the interviewer ensures that --

i. every opportunity is provided for the teacher to reveal as completely as possible all details of his (her) plan;

ii. every precaution is taken against saying or doing anything in the interview which may influence the teacher to withhold, or change, details of lesson plans; even so, the very act of talking about the plans may cause the teacher to modify them.

To ensure that the goals of the interview will be achieved as fully as possible, these guidelines are to be followed by the interviewer:

After the initial question (see attached) has been asked and responded to by the teacher, it will usually be necessary to ask 'follow-up' questions. The nature of the 'follow-up' questions should be largely dependent upon what the teacher says and should seek clarification of the teacher's previous responses or should invite the teacher to extend the previous responses.

Avoid asking 'leading' questions viz., those which provide alternatives from which the teacher has only to choose or which involve mentioning other aspects of planning to which the teacher may not have given consideration.

Avoid asking questions which are based on inferences you may have made from the teacher's comments.

When phrasing 'follow-up' questions, use the teacher's own words as much as possible; do not rephrase the teacher's comments in your own words.

Be neutral; do not offer or express an opinion about the plans or goals even if asked; avoid making judgmental or evaluative comments.

PROCEDURES FOR CONDUCTING PREACTIVE INTERVIEW

Part A

1. Interviewer says:

> During the lesson we are videotaping today/tomorrow we shall be keeping a record of classroom events. To be able to place this record in its proper perspective it is necessary to know what your intentions are, what you are setting out to do in the lesson. In this interview you will be asked one question about the goals of the lesson you are about to teach. Please answer the question as fully as possible but do not say anything in your response to this question which you had not thought about prior to this interview.

2. Record the following details on the form supplied which is to be kept with the tape:

   Name of teacher

   Name of school

   Grade

   Lesson topic(s)

   Date when lesson is to be taught.

Turn on the audio-tape recorder at this point.

3. Ask the 'initial' question:

   What are the goals of this lesson/unit of work?

4. Ask 'follow-up' questions to ensure that the goals of the interview are achieved.

   Examples: Can you explain more fully what you meant by "   "?

   What other goals do you hope to achieve in this lesson?

   Do you have anything more you want to say about the goals of the lesson? (This question should be repeated until the teacher answers in the negative.)

Part B.

5. Interviewer says:

   Now I would like to move on to the second part of the interview. At this point you will be asked about the plans you have made for achieving the goals of the lesson you outlined earlier. The plans may be in written form or they may be in unwritten form - you may have thought out what you were going to do in the lesson without committing yourself to paper. In this interview please indicate the nature of the plans you have made for achieving the goals of the lesson whether they are in written or unwritten form. Answer the question as fully as possible but do not say anything in your response which you had not thought about prior to this interview.

6. Ask the 'initial' question:

   How do you intend to achieve the goals of the lesson?

7. Ask 'follow-up' questions to ensure that the goals of the interview are achieved.

   Examples: Did you plan to do anything else?

   Were there any other aspects of the lesson that you had given thought to?

How had you planned to do that?

Have you anything more to say about the plans you had made for achieving the goals of the lesson? (This question should be repeated until the teachers answers in the negative.)

8. Then ask:

Did you mention anything in your answers to the questions which you hadn't thought of before the interview?

Do you think that discussing your plans in this interview changed them in any way? If so, how?

APPENDIX B

ANALYSIS OF PREACTIVE INTERVIEWS

ANALYSIS OF PREACTIVE INTERVIEWS

Preactive interviews were conducted with each teacher prior to videotaping each lesson to ascertain the lesson goals and objectives set by the teacher as well as plans made for achieving these lesson goals. The guidelines for the conductance of the interviews as established by Marland (1977) were strictly adhered to. The preactive interview data was analyzed according to the following four categories:

(1) Goals/purposes.

(2) Instructional Delivery Systems.

(3) Instructional Strategies.

(4) Content Structure and Sequence.

The preactive interviews with teachers in the pilot study yielded considerably more information than did those in this study. In the latter case, much less time was available for these interviews as the teachers were responsible for a number of supervisory duties prior to the videotaped lesson. Noticeably absent in these interviews was any mention of the broader goals of math instruction. The information obtained from these interviews served an orientation purpose for the researcher rather than an analytical purpose designed for research on teacher planning per se. The purpose in obtaining preactive interview data was to relate instructional behavior and pupil learning to pre-disclosed objectives and planned strategies.

The responses to the two questions

(a) Did you mention anything in your answers to the questions which you hadn't thought of before the interview?

(b) Do you think that discussing your plans in this interview changed them in any way?

were "No" except for one teacher who responded to question (a) as follows:

T: Yeah, I think so.

I: Can you explain what you mean?

T: I'd have to think about that. I know that I had that thought. But it was just something tiny and that's why I was saying it doesn't make much difference in my plan. It's something maybe I just didn't think of in words and now I've said it in words, type of thing... No, I don't think it'll make any difference in my lesson. But it - - well maybe it would. Maybe if putting it in words is clearer than abstract, maybe I'll be teaching it a little clearer. I don't know.

LESSON A-1, TOPIC: Equivalent Fractions, Grade 4.

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
Students get additional practice working with fractions.	Teacher Concrete materials for demonstration	Review fractions Demonstrate equivalence with a physical entity (Concrete-iconic).	Simple fractions 2/4 = 1/2
Introduce simple equivalent fractions and expand to others.	Blackboard	Use a pie cut in fourths to illustrate equivalence. (enactive)	1/8
Students add a skill to the 10 fraction skills required in grade 4.	Printed material (Math text book)	Use examples in math text and demonstrate on board. Pupil-teacher interaction throughout the lesson. Do examples in text mentally while teacher starts grade 5 with worksheet. Students work individually on an exercise from the text.	

LESSON A-1, TOPIC: Decimals, Grade 5

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
Students get additional practice in working with decimals.	Teacher Blackboard	Students work individually on worksheets.	Add 1/10ths and 1/100ths.
Students be able to add decimals in different forms.	Printed material (mimeographed work sheets)	Teacher demonstrate a few examples on board.	Place value of 1/10ths and 1/100ths and convert to decimals.
Students be able to convert decimals from one form to another.	Teacher Blackboard	If student difficulties use text to reinforce or do more examples on the board.	Decimals as fractions. Fractions as decimals.
Contingency goals based on student responses.	Printed material (mimeographed work sheets)	Teacher-pupil interaction on place value and conversions .	Conversion of decimals to reduced forms.
Achieve an additional skill in the sequence of decimal skills for grade 5.		Teacher works examples on board. Students work individually on worksheets.	

LESSON A-2, TOPIC: Review of Equivalent Fractions and Related Topics, Grade 4

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
Go ahead in the text.	Teacher	Review last lesson content.	Equivalent fractions
Review 3 or 4 related concepts.	Blackboard Math text	Do 2 pages in text using board demonstration, pupil-interaction and discussion.	Generate sets of equivalent fractions.
		Do one page in text using board demonstration and discussion.	Numerators and denominators.
		Do pages in text together. Students do assigned exercises from text.	Improper fractions and mixed numbers.

LESSON A-2, TOPIC: Addition and Subtraction of Decimals, Grade 5

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
Students able to add and subtract decimals.	Teacher Blackboard	Teacher demonstrates position of place value by columns.	Add decimals. Line up decimals in correct place value before adding.
Students able to align numbers by place value before adding or subtracting.	Worksheets	Teacher does examples on board and discusses with students.	Line up decimals with empty digit places.
		Teacher demonstrates examples of subtraction.	Subtract decimals.
		Students do worksheets individually.	Addition and subtraction of decimals.

LESSON B-1, TOPIC: Multiples, Grade 6

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
Pupils understand what multiples are.	Teacher	Teacher introduces the topic.	Multiples of natural numbers.
Pupils know how to apply multiples.	Blackboard Pupils Math text	Teacher does examples on board following the text outline.	Use examples in math text.
At least 90% of pupils understand how to find common multiples by end of lesson.	Review sheets	Teacher-pupil interaction during teacher demonstration.	Compare multiples with common factors.
		Pupils to board to try examples. Correct pupil examples on board with pupil interaction. Review concept and check for individual difficulties. Pupils do review sheets. Assign work from the text.	Differentiate between functional use of common factors and common multiples.

LESSON B-2, TOPIC: Fractions, Grade 6

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
Have pupils recall previous knowledge of fractions and review this. Pupils able to set up simple fractions. Pupils able to show what fractions represent. To have pupils understand simple fractions.	Teacher Board Overhead projector Math text Concrete materials	Introduce what fractions are. Compare fractions with whole numbers. Do examples on board. Manipulate fractions on overhead projector using concrete materials. Pupil-teacher interaction during each of the above. Pupils do exercise in math text.	Simple fractions from 1/2 to 1/10.

LESSON C-1, TOPIC: Division (zero in quotient), Grade 4

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
Pupils are able to divide with a one-digit divisor. Introduce a zero in the quotient and have pupils understand how to handle it. Have pupils understand place value. Have pupils interpret remainders if any occur. Establish some competition within the class.	Teacher Blackboard Worksheet	Direct instruction. Some aspects of lesson presentation written out prior to lesson. Contingency strategies based on pupil responses. Demonstrate one example. Pupils work examples. Conduct a contest between teacher and pupils and award points to the winner. Monitor the number of pupils who get the answer on first attempt. When all pupils understand concept give assignment (worksheet). Re-teach at small table to those few having difficulty.	Demonstration of example couched in a problem situation. Additional examples worked by students.

LESSON C-2, TOPIC: Division (Partial Quotient Method), Grade 4

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
To introduce the partial quotient method of division. To increase pupils' understanding that division is repeated subtraction from the dividend. To increase pupils' understanding of place value by looking at it in a different way.	Teacher Blackboard	Teacher directed lesson. Teacher demonstrates one example. Students proffer examples and work at individually. Correct examples with pupil interaction.	One example of partial quotient method. Additional examples of partial quotient method using a one-digit divisor.

LESSON D-1, TOPIC: Addition and Subtraction of Fractions with Different Denominators, Grade 5

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
To have pupils able to add and subtract fractions with different denominators. To have pupils show their work and record the algorithm. To have pupils build sets of equivalent fractions.	Teacher Math text Overhead projector	Group instruction. Teacher demonstrates examples on overhead. Teacher-pupil interaction during demonstration. Assess time for number of practice questions pupils can handle during the work period. Pupils work individually on practice questions.	Build sets of equivalent fractions for each fraction. Several examples of addition of fractions. Build sets of equivalent fractions for each fraction. Several examples of subtraction of fractions.

LESSON D-2, TOPIC: Addition and Subtraction of Fractions (Continued), Grade 5

GOALS/PURPOSES	INSTRUCTIONAL DELIVERY SYSTEMS	INSTRUCTIONAL STRATEGIES	CONTENT STRUCTURE AND SEQUENCE
Pupils get additional practice in adding and subtracting fractions with different denominators. Clear up individual difficulties.	Teacher Math text Overhead projector	Group checking of previous assignment. Discuss difficulties on assignment. Group instruction using additional examples. Teacher and pupil demonstrations on overhead projector. Pupils work individually on practice questions. Individual help during seatwork.	Simple fractions added and subtracted. No re-grouping or rearranging of fractions and mixed numbers. Larger fractions added and subtracted.

APPENDIX C

MATERIAL TO BE PRESENTED TO, AND DISCUSSED WITH THE INTERVIEWEE

(TEACHER)

MATERIAL TO BE PRESENTED TO, AND DISCUSSED WITH THE INTERVIEWEE (TEACHER)

Introduction

During the past ten years "Teaching" has received increased emphasis from educational researchers. A number of researchers have maintained that research into teaching can only take place in the classroom and that through observation of the teacher's overt actions information can be gained that will assist in the development of theories of instruction. However, to more fully develop theories of instruction and improve teacher education and school curricula, researchers have also postulated the need to understand teachers' thought processes.

Objectives of the Research

At the present time very little is known about teachers' thought processes during instruction. These processes are the focus of interest of this research project. The objective of this research is to find out what information teachers use during instruction, why they use this information and how they process this information. The decisions teachers make and the reasons for those decisions is of special interest. How well the lesson was taught is NOT the focus of the interview.

Role of the Teacher/Interviewee

The method used in this research project to obtain data on teachers' information processing during instruction is called "stimulated recall." Asking teachers to recall after a lesson the thoughts and feelings they experienced whilst actually teaching the lesson has not proved very satisfactory. Recall of thoughts and feelings is facilitated when teachers are shown a videotape of the lesson. Seeing events in the lesson on videotape helps to trigger or stimulate recall - hence the term "stimulated recall."

Whereas it is possible to have people in some professions "think out loud" about their professional duties because they are not interacting with other people, it is not possible to do this with teachers because it would interfere with the instructional process.

We know that the mind works faster than the voice. As teachers interact with children in the classroom they:

- become aware of many more classroom events than can be inferred from their verbal and overt non-verbal behavior;
- react to classroom events intellectually and emotionally in ways which even the most perceptive observer could not detect because they are internal. Many re-

actions, interpretations and diagnoses of pupil behavior are not revealed to the observer.

- make numerous decisions about what to do and say next or at some future point in the lesson, or what not to do or say. The alternative courses of action considered, the reasons for the final choice of action are frequently not declared or revealed; the observer is not privileged with this "inside" knowledge and with the various rationales used to make decisions.
- use many rules, principles and instructional strategies that the observer is not aware of.

As the teacher relives the lesson by viewing the videotape, he/she is invited to provide a detailed account, to talk aloud, about:

(a) thoughts, feelings, moment-to-moment reactions;

(b) conscious choices (i.e. when you chose to do or say one thing rather than other things, or when you chose to say or do nothing), the alternatives you considered before making a choice, and the reasons for choosing to do or say that particular thing.

Note: 1. You may stop and start the tape as often as you wish.

2. The interviewer may also stop the tape on some occasions to ask you if you can recall your thoughts, feelings, reactions, etc. in relation to certain class-

room events.

3. The interviewer's role is simply to assist you to recall what you thought and felt during the lesson.
4. As you view the tape you will probably form new impressions of the lesson and of events which occurred during the lesson, and think of other things that you might have said or done. Try to distinguish during the interview between the thoughts and feelings you had during the lesson and those you had after the lesson or when watching the videotape; ensure that the interviewer is aware of the distinctions too.

If you have any questions, the interviewer will be pleased to discuss these with you prior to the interview.

APPENDIX D

GUIDELINES FOR PUPIL STIMULATED RECALL INTERVIEWS

GUIDELINES FOR PUPIL STIMULATED RECALL INTERVIEWS

During the familiarization week in the school

(1) select students to be interviewed from grade four, five and six,

(2) establish a comfortable rapport with each student,

(3) discuss briefly with the student, the nature of the "stimulated recall" part of the research and the sequence of events relating to it so that the stimulated recall interview can follow as soon as possible after the lesson has been videotaped and previewed, and

(4) discuss any questions which the student may have about stimulated recall prior to the interview.

Discuss with the student the goals of the research:

Little is known about the student's thought processes during instruction. The goal of this research is to find out the thoughts, feelings, moment-to-moment reactions and perceptions of the student during the instructional process. (i.e. re: cognitive interaction, classroom events, math content, instructional strageties, the teacher, the class, etc.) Viewing the videotape of the lesson facilitates recall of thoughts and feelings. Since individual student talk constitutes such a minor portion of classroom interaction, even the most perceptive observer cannot detect his (her) emotional and intellectual reactions to classroom events; nor can the student's enjoyment of the lesson, understanding of the content and awareness of many classroom events always be inferred from his (her) verbal and non-verbal behavior.

It is considered that a study of these processes could yield insights which would assist in the development of theories of instruction which in turn could lead to the improvement of teacher education programs.

How well the student behaves or how well s(he) achieves is not the focus of the interview. Impress upon the student that the stimulated recall interview is not a memory test nor a test of any kind. S(He) should consider the (taped) lesson as an ordinary lesson and behave or react as s(he) naturally would. All research data is confidential.

Prior to the Viewing

1. Preview the videotape of the lesson to identify those segments which appear most significant for investigating the thought processes of the student.
2. Arrange the interview setting so that the interviewee can look directly at the monitor and will not be distracted by the interviewer.

4. Spend some time in viewing the videotape before starting the interview, particularly if the student has never viewed him (her)self on videotape before.
5. Explain to the student that s(he) will probably form new impressions of the lesson and of the events which occurred during the lesson while viewing the tape. Ask him (her) to try and distinguish during the interview between the thoughts and feelings s(he) had during the lesson and those s(he) had after the lesson or when watching the videotape.

Role of the Interviewer

In the stimulated recall session with the student, the role of the interviewer is to assist the student to recall and verbalize the covert thoughts and feelings s(he) had during the lesson which has been videotaped. To facilitate as complete and as accurate recall as is possible the interviewer must:

- try to establish a relaxed, friendly, supportive atmosphere prior to and during the interview;
- try to faciliate and encourage self-discovery; it is important for the interviewee to believe that s(he) is capable of telling about inner proeceses without the interviewer telling the interviewer what they were;

- avoid making interpretations of, and judgments about, what appears on videotape; ask questions requiring elaboration or clarification but avoid questions answerable by "yes" or "no";
- assume a respectful set towards the student and the videotaped material; communicate to the interviewee that s(he) is being taken very seriously;
- keep the student's attention focused on the TV image; refrain from unnecessary activity as such activity may actually interfere with recall;
- encourage the interviewee to talk; don't have him (her) become so engrossed in listening to you that s(he) forgets what s(he) is reliving; the interviewee is the authority;
- be patient; give the interviewee a chance to become involved in reliving the recorded lesson;
- immerse yourself in the interviewee's communication rather than trying to figure out what to say next;
- keep the student's discussion focused on what transpired in the actual videotaped lesson and, in particular, on the student's covert thoughts, feelings and the sources of these;
- stop the tape (if the student has not already done so) at points in the lesson where it appears likely to be profitable for purposes of this research and at the following

points identified during a preview of the videotape;

1. When the teacher asks a question of the student (or another student).
2. When the student's (or another student's) answer to a question is part-correct or incorrect.
3. When a student-initiated question (relevant) occurs.
4. When a student-initiated comment (relevant) occurs.
5. When the teacher responds to a student's answer.
6. When there is a behavior-related teacher-afforded warning.
7. When there are non-verbal cues suggesting that the teacher (or student) is anxious, annoyed, perplexed, excited, enthusiastic, etc.
8. When the lesson is not running smoothly.
9. When the student interacts with other students.

- ask probing questions to facilitate maximum disclosure by the student, e.g.,

  What were you thinking, feeling at that point?
  Why did you say, do .... ?
  Did you have any reasons for saying, doing ...?
  Did you understand what the teacher was saying, doing ...?
  What did you think the teacher was wanting, thinking ...?
  Can you recall any other kinds of thoughts you had?
  Were there any fantasies (day-dreams) going through your mind?

Was there anything that you did not want to happen?
Was there anything that you wanted to do at that time?

Note: Questions should be brief and should create an intense awareness in the student of him (her)self. Avoid questions which are suggestive of, or imply, criticism, incredulity, disagreement, disapproval, etc.

- Check frequently that the student is differentiating between interactive thoughts and feelings and those subsequently formed.

APPENDIX E

DESCRIPTIONS OF CATEGORIES IN SATIT

Descriptions of Categories in SATIT

NAME OF CATEGORY	DEFINITION	EXAMPLES OF PROCESSES	EXAMPLES OF REFERENTS OR ITEMS
1. Perception	Unit in which the teacher reports a sensory experience (what was seen, heard, noticed, smelt, etc.) during the lesson; a perception signifies awareness.	sees; hears; notices; feels; smells.	pupils; pupil behaviors; objects; materials; sounds; activities.
2. Interpretation	Unit in which the teacher reports the personal meaning s(he) attaches to a perception of a pupil.	interprets; explains; describes; imputes; attributes.	perceptions
3. Tactical deliberations (prospective)	Unit in which the teacher identifies or discusses what s(he) plans to do at some future point in the lesson or beyond it.	compares; contrasts; evaluates; asseses; names; lists; identifies.	planned teacher action.
4. Tactical deliberations (retrospective)	Unit in which the teacher is discussing a course of teacher action which s(he) has already used in the lesson.	evaluates; considers; recalls; lists; criticizes.	past teacher action.

NAME OF CATEGORY	DEFINITION	EXAMPLES OF PROCESSES	EXAMPLES OF REFERENTS OR ITEMS
5. Reflection	Unit in which the teacher considers what has already occurred within the lesson (excluding tactics of the teacher).	evaluates; considers; compares; contrasts; recalls.	past events; experiences; perceptions; interpretations.
6. Anticipation	Unit in which the teacher predicts or speculates on probable future events and outcomes or the future consequences of recent events.	speculates; conjectures; predicts; hopes; expects.	events; results; outcomes; consequences.
7. Information - pupil	Unit in which the teacher recalls or attempts to recall information about a pupil, his (her) background, etc., which was brought to the lesson.	knows; believes; assumes; recalls; remembers.	demographic details; beliefs; facts; impressions; expectation of pupils.
8. Information - other	Unit in which the teacher recalls or attempts to recall all other information held by him (her) before the lesson.	knows; believes; assumes.	lesson content; lesson plans; school policies; professional knowledge.

NAME OF CATEGORY	DEFINITION	EXAMPLES OF PROCESSES	EXAMPLES OF REFERENTS OR ITEMS
9. Goal Statement	Unit in which the teacher declares what pupils are to achieve.	plans; sets; intends; wants.	pupil objectives.
10. Fantasy	Unit in which the teacher expresses fanciful, exaggerated, weird, bizarre thoughts.	fantasizes; daydreams.	people; students; self; events.
11. Feelings	Unit in which the teacher reports an emotional experience or affective state.	feels; experiences; reacts.	emotion.

APPENDIX F

CONTENT ANALYSIS FOR PUPIL INTERACTIVE THOUGHTS (CAPIT)

CONTENT ANALYSIS FOR PUPIL INTERACTIVE THOUGHTS (CAPIT)

Introduction

Although introspective techniques have been used to study the cognitive functioning of teachers during instruction, very little use of these techniques has been made in studies which focus on the cognitive functioning of pupils during instruction. Since the kinds of information processed by pupils during instruction partially determine the amount of learning that occurs, an analysis of that information could yield insights into the learning process, pupils' interpretations of the instructional process, and means of optimizing the instructional process.

After comparing the results of several content analysis systems for categorizing pupil interactive thoughts, this system was chosen for categorizing the research data. It distinguishes between pupil interactive thoughts which focus on lesson content from thoughts which reveal the foci of pupil monitoring. Relative to alternate systems, it facilitates more readily the description and interpretation of pupil interactive thoughts in terms of selected theoretical constructs.

Data

Transcripts prepared from audio-tapes of interviews with pupils are coded by CAPIT. A stimulated recall technique was used to obtain the interview data. This technique requires introspection by the pupil which is stimulated by showing the pupil a video-tape of a lesson taught on the same day. The pupil is asked to recall and report the thoughts and feelings that s(he) had during the lesson. The interviewer operates all audio-video equipment and through minimal interjection facilitates recall and maximum disclosure of the pupil's interactive thoughts and feelings. Segments containing dialogue between pupil (P) and interviewer (I) are demarcated in the transcripts indicating points at which the video-tape is stopped following a signal from the pupil that s(he) had recalled his (her) interactive thoughts or feelings.

Coding

The first step in this system is to distinguish between non-interactive (preactive or postactive) data and interactive data. Prior to the interview, the pupil was asked to recall only those thoughts and feelings that s(he) had during instruction. The transcripts contain questions by the interviewer and confirming statements by the pupil which provide clues as to whether or not the pupil is recalling interactive thoughts and feelings. The following examples indicate some of the clues which provide guidelines for identifying interactive data.

I: What did you think there?

P: Well, s(he) had his (her) story a bit mixed up ....

I: Did you hear it in class?

P: Yeah, I heard it.

The examples below contain clues for identifying non-interactive thoughts.

P: I was thinking now that ....

I: Oh. That's what you were thinking then or now?

P: Now.

I: Worried ? (I was referring to the pupil's previous remark.)

P: Yeah, but I should have known that when you put in the zeros it doesn't do anything.

The next step in this system is to divide the pupil recall data into thought units. The dialogue by the interviewer is not analyzed. The unit in CAPIT is defined as a segment of the protocol which focuses on a single thought where referents consist of events, lesson content, ideas, and people.

The last step is the categorization of interactive units. Each unit is classified as one of the following discrete categories.

Mathemagenic Orientation (MO)
Mathemagenic Encoding I (ME-I)
Mathemagenic Encoding II (ME-II)
Monitoring-Self (MS)
Monitoring-Teacher (MT)
Monitoring-Peer (MP)
Feelings (F)
Information-Relevant (IR)
Information-Irrelevant (II)
Extraneous (EX)
Ecological (EC)

Each unit is categorized on the basis of its distinct features. The following definition of categories and examples of categorized units are used as a basis for categorization.

1. Mathemagenic Orientation (MO)

This category includes all units in which the pupil reports that s(he) has perceived or is perceiving a stimulus relevant to the mathematical content of the lesson. Such units are comprised of perceptions. They include actions or verbalizations by either the teacher or a pupil(s) with reference to the mathematical components of the lesson as well as perceptions of curricular materials. In some instances encoding of information relative to mathematical curriculum materials (other than mathematical content) may have occurred. These perceptions constitute the lowest level of attention, the name for processes in which nominal stimuli are translated by learners into effective stimuli. They are indicative of an orientation of the receptors (pupils) toward the stimuli. Whether or not these potential stimuli give rise to learning depends on further mediating cognitive processes carried out by the pupil. These reported perceptions merely indicate that the pupil has seen or heard things which orient him (her) to the mathematical content of the lesson.

Examples:

P: S(He) said to go get our math books.

P: S(He) put down a different number s(he) used.

P: S(He)'d tell me that answer that s(he) was going to say.

P: S(He) said like, we were going to be doing adding and subtracting of decimals.

P: S(He) passed out the blue work sheets.

P: S(He) said, "No, you can't do that.".

P: Like most sheets were blurry.

2. Mathemagenic Encoding I (ME-L)

Encoding of the stimulus is a second process in attention. It signifies that the pupil has responded to one or more aspects of the stimulus. Units categorized as ME-I are those which indicate that the pupil was encoding or attempting to encode the mathematical stimuli. Whether the pupil was able to translate the perceived stimuli into a personally meaningful form is not a criterion for categorizing the thought unit as ME-I.

Examples:

I was thinking about the math problem.

I was thinking about what the answer could be.

I was thinking about the equations.

I was already thinking of how I did that.

I was trying to figure out how to add 1/24 and 1/15.

I was wondering what they were (digits in the quotient).

I was reviewing the answer in my mind.

3. Mathemagenic Encoding II (ME-II)

This category constitutes a level of encoding in which the pupil has encoded or translated that mathematical stimuli perceived during the lesson, into a personally meaningful form. The accuracy of this encoding is not a criterion for categorizing the thought unit as ME-II. This translation of mathematical stimuli may be based upon stimuli provided by the teacher, other pupils or curriculum materials.

Examples:

P: Like you had to figure out these fractions before, ah, you could figure out the code.

P: S(He) was talking about moving the zero from one place to a different place and thinking that the decimal would stay the same.

P: S(He) did it in kind of a weird way.

P: S(He) got the right answer.

P: I knew how to do it.

P: I understood it.

P: It's so easy.

P: I had my hand up for 12.

P: I figured it out.

P: There were two (symbols) that looked exactly the same.

4. Monitoring-Self (MS)

These units indicate that the pupil is aware of and monitoring his (her) own actions and thoughts (excluding his (her) feelings) during the lesson. They include anticipations, reflections, goals, evaluation, and introspections. There is no explicit reference to the mathematical content of the lesson in these units. A distinguishing feature of these units is that most of the statements start with the pronoun "I".

Examples:

P: I couldn't see the board.

P: I didn't understand.

P: I had my hand up on all the questions.

P: I was the only person that knew how to do it.

P: I was looking at the board.

P: It took me a while ....

P: I wanted to finish....

P: I had two questions left to do.

P: I asked my friend....

P: I would have somebody to discuss it with.

P: I didn't have anything to do.

5. Monitoring-Teacher (MT)

The focus of these units is on the teacher. They reflect an attempt on the part of the pupil to interpret what is going on in the mind of the teacher. A second feature of this category is that the unit may contain a pupil reflection on overt teacher behavior. In both instances, there is no explicit reference made to the mathematical content of the lesson.

Examples:

P: S(He) didn't ask me.

P: I guess s(he) didn't want to.

P: S(He) answered most of them him (her)self most of the time.

P: S(He) finally guessed it.

P: S(He) didn't explain it very well.

P: S(He) asked Diane.

6. Monitoring Peers (MP)

In this category, the focus of the pupil's thought is on the behavior of other pupils. This behavior may be overt or covert but no explicit reference is made to mathematical content. These units may be perceptions, reflections, evaluations, or interpretations.

Examples:

P: There was only one other person that had their hand up.

P: S(He) was saying, "I don't know how you did that Valerie.".

P: Most of the kids didn't know it.

P: They came to ask me how you do it.

P: S(He) can't pronounce it that good.

P: S(He) handed out the snacks.

P: S(He) helped me.

7. Feelings (F)

Units in which the pupil reports an emotion experienced during the lesson are easily identified and are coded as F. Pupil statements about affective states refer to feelings such as boredom, frustration, surprise, pleasure, and annoyance.

Examples:

P: I kind of felt a bit mad....

P: And I was happy too.

P: I felt kind of good....

P: It was just boring.

8. Information-Relevant (IR)

These thought units include items of information which the pupil possessed prior to the lesson. They may refer to him (her) self, his (her) behavior, his (her) predispositions, to other pupils, the teacher or curricular concerns. The accuracy of the information is not a criterion for categorization. The information in these units is related to events that have occurred during the lesson.

Examples:

P: I like doing the work sheets.

P: I usually help him (her).

P: I've done it already.

P: S(He) wasn't as good at it as I was.

P: _____ had gone yesterday to get the snacks.

P: They're (referring to work sheets) fun.

P: I like finishing first because ....

P: S(He) said that, like we'd go in a pattern.

9. Information-Irrelevant (II)

Units containing information which has no relationship to events that have occurred during the lesson or to lesson content are coded as II. They refer to past or future events.

Examples:

P: Well, we have a practical arts program ....

P: My friend and I are doing a dance and ....

10. Extraneous (EX)

Thoughts which the pupil had during the lesson and which are unrelated to events that have occurred in the lesson or to lesson content are coded as (EX). Collectively, they represent distractions from the mathematical components of the lesson. They are usually directly related to the irrelevant information proffered.

11. Ecological (EC)

Pupil interactive thoughts about environmental features such as time, temperature, noise, and so on are coded as ecological (EC). All reported interactive thought which focused on the videotaping of the lesson are also coded as EC.

While contextual clues facilitate CAPIT coding of interactive units, they are particularly helpful and often necessary for categorizing mathemagenic encoding (ME-II) units. A helpful strategy for initial categorization is coding by elimination. That is, none of the last 8 categories contains references to the mathematical content of the lesson. Statements such as, "I didn't understand it." or "I was confused." incidate that attempts to translate mathematical stimuli into a personally meaningful form have been unsuccessful and are coded as Monitoring-Self (MS) units.

APPENDIX G

BAMS AND BAMIS

BELIEFS ABOUT MATHEMATICS SCALE(BAMS)

Directions: Draw a circle around the letter(s) that show(s) how closely you agree or disagree with each statement.

SD - strongly disagree
D - disagree
U - undecided
A - agree
SA - strongly agree

---

1. Solving a mathematics problem usually involves finding a rule or formula that applies. SD D U A SA
2. The field of math contains many of the finest and most elegant creations of the human mind. SD D U A SA
3. The main benefit from studying mathematics is developing the ability to follow directions. SD D U A SA
4. The laws and rules of mathematics severely limit the manner in which problems can be solved. SD D U A SA
5. Studying mathematics helps to develop the ability to think creatively. SD D U A SA
6. The basic ingredient for success in mathematics is an inquiring nature. SD D U A SA
7. There are several different but appropriate ways to organize the basic ideas in mathematics. SD D U A SA
8. In mathematics there is usually just one proper way to state something. SD D U A SA
9. In mathematics, perhaps more than in other fields, one can find set routines and procedures. SD D U A SA
10. Math has so many applications because its models can be interpreted in so many ways. SD D U A SA
11. Mathematicians are hired mainly to make precise measurements and calculations for scientists. SD D U A SA
12. In mathematics, perhaps more than in other areas, one can display originality and ingenuity. SD D U A SA
13. There are several different but logically acceptable ways to define most terms in math. SD D U A SA
14. Math is an organized body of knowledge which stresses the use of formulas to solve problems. SD D U A SA
15. Trial-and-error and other seemingly haphazard methods are often necessary in mathematics. SD D U A SA
16. Mathematics is a rigid discipline which functions strictly according to inescapable laws. SD D U A SA
17. Many of the important functions of the mathematician are being taken over by the new computers. SD D U A SA

18.Mathematics requires very much independent and original thinking. SD D U A SA

19.There are often many different ways to solve a mathematics problem.SD D U A SA

20. The language of math is so exact that there is not much room for variety of expression. SD D U A SA

BELIEFS ABOUT MATHEMATICS INSTRUCTION SCALE (BAMIS)

Directions: Draw a circle around the letter(s) that show(s) how closely you agree or disagree with each statement.

SD - strongly disagree
D - disagree
U - undecided
A - agree
SA - strongly agree

---

1. The teacher should always work sample problems for students before making an assignment. SD D U A SA
2. Teachers should make assignments on just that which has been thoroughly discussed in class. SD D U A SA
3. Children should be encouraged to invent their own mathematical symbolism. SD D U A SA
4. Each student should be encouraged to build on his own mathematical ideas, even if his attempts contain much trial and error. SD D U A SA
5. Each student should feel free to use any method for solving a problem that suits him best. SD D U A SA
6. Teachers should provide class time for students to experiment with their own mathematical ideas. SD D U A SA
7. Discovery methods of teaching tend to frustrate many students who make too many errors before making any hoped-for discovery. SD D U A SA
8. Most exercises assigned to students should be applications of a particular rule or formula. SD D U A SA
9. Teachers should spend most of each class period explaining how to work specific problems. SD D U A SA
10. Teachers should frequently insist that pupils find individual methods for solving problems. SD D U A SA
11. Discovery methods of teaching have limited value because students often get answers without knowing where they came from. SD D U A SA
12. The teacher should provide models for problem solving and expect students to imitate them. SD D U A SA
13. The average mathematics student, with a little guidance, should be able to discover the basic ideas of mathemtics for himself. SD D U A SA
14. The teacher should consistently give assignments which require research and original thinking. SD D U A SA
15. Teachers must get students to wonder and explore even beyond usual patterns of operation in math. SD D U A SA

16. Teachers must frequently give students assignments which require creative or investigative work. SD D U A SA

17. Students should be expected to use only those methods that their text or teacher uses. SD D U A SA

18. Discovery-type lessons have very limited value when you consider the time they take up. SD D U A SA

19. All students should be required to memorize the procedures that the text uses to solve problems. SD D U A SA

20. Students of all abilities should learn better when taught by guided discovery methods. SD D U A SA

APPENDIX H

PERSONAL AND PROFESSIONAL DATA QUESTIONNAIRE

PERSONAL AND PROFESSIONAL DATA QUESTIONNAIRE

Please complete each of the items below.

1. Number of years of teaching experience as of June 30, 1978. ....

2. Grades taught in your last 5 (or less) years of teaching. ....

   ....

3. Degree(s) held in Education (or other areas) and the year obtained.................

   ....

4. Area(s) of specialization in your undergraduate and graduate training...............

   ....

5. Field of Specialization. (The ONE subject area for which you consider yourself to be MOST adequately prepared to teach.) ....

6. University courses taken in Mathematics Methodology (ED CI courses or equivalent. Please indicate whether half course or full year course.) ....

   ....

   ....

7. University courses taken in mathematics in a faculty of science or arts. (Please indicate whether half course or full year course.)..................................

   ....

8. Your age (last birthday). Check one.
   1. Under 25 years .....
   2. 25-30 years......
   3. 31-35 years.....
   4. 36-40 years.....
   5. Over 40 years.....

9. Subject area which you enjoy teaching most in elementary school..................

10. Your recent activities (last 2 or 3 years) in any mathematics association, council, curriculum development, or professional activities related to mathematics teaching.

    ....

    ....

    ....

    ....

NOTE: Please use the reverse side for comments or additional information regarding the above.

APPENDIX I

SIMILIAR NODAL DIALOGUE (PUPILS)

SIMILIAR NODAL DIALOGUE (PUPILS)

Student AA-2-2 and Student AA-2-3

Question 1: What did it mean to you when the teacher said "Quickly now, grade 5."?

AA-2-2: ... There's only about so minutes left then. And so s(he)'d have to hurry and we'd have to hurry up too or else we wouldn't get finished.

AA-2-3: It meant that - I thought it would be easy because if it's usually hard it takes long 'cause s(he) (the teacher) knows whether it's hard or not for us. So I guess s(he) said "quickly" 'cause s(he) knew it was easy.... It wouldn't take long for us to learn.

Question 2: Did you hear him (her)(the teacher) say "Leslie."?

AA-2-2: Ah, I don't remember. I don't think so though because when s(he) was talking I think I was talking to Mike because Mike and I both knew this.

AA-2-3: Yeah

I: What did it mean to you?

S: I don't know.

I: Do you know what the teacher meant:

S: Yeah. S(He) was asking him (her) a question. (It was actually a teacher reprimand to Leslie.)

Question 3: What were you thinking then?

AA-2-2: S(He) didn't get the question. Like I kind of thought, hurry up V_____ because, you know, we don't have much time left. And, ah that we were going to run out of time before s(he) could explain it all.

I: Did V_____ get it right?

S: Yes but s(he) did it in kind of a weird way. It got Mike all confused and then I thought if s(he) does it that way, everybody else will do it that way and they'll get confused.

AA-2-3: V_____ made a mistake and s(he) didn't work it out or try to fix it up .... I was thinking something like V_____ wasn't awake this morning. S(He)'s usually on the ball.

Question 4: Why did the teacher have a student come up and do the question on the board?

AA-2-2: Well probably because s(he) (the teacher) wants to see if some of the other kids know how to do it.

AA-2-3: Well, I guess to see if s(he) knows it and other people know it.

Question 5: What is the teacher doing there?

AA-2-2: Well it was just borrowing. It wasn't anything new. So I knew all that anyway.

AA-2-3: S(He)'s putting in his (her) zeros. Well they don't indicate anything but s(he) just puts them in.

I: What did you think about that?

S: Well, again I got kind of worried.

Question 6: Do you remember what you were thinking then?

AA-2-2: I told him (her) that was grade one stuff and then s(he) got mad at me and wouldn't talk to me for about 20 minutes.

AA-2-3: I was kind of laughing at J_____ 'cause s(he) added 7 and 5 wrong.

Question 7: What were you thinking then?

AA-2-2: Well, like s(he) said that we'd do some work sheets later and so I thought it was going to be later this morning like after recess. But then s(he) said another day. Like I felt kind of mad at him (her) because .... like we had, I think about 10 minutes before the snacks came and so I was ready to do a couple of work sheets in that 10 minutes.

AA-2-3: I was relieved 'cause I thought the sheets would be hard again.

Question 8: Do you remember what you were thinking there?

AA-2-2: Well like, ah T_____ had gone yesterday to get the snacks. And like s(he) was going to get them again today. Mr(s) _____ said that like we'd go in a pattern. And then when s(he) changed the pattern I got kind of mad because then I'd have to wait a long time before I could get the snacks again.

AA-2-3: I was glad there because we were having snacks today instead of yesterday. We usually have it on Thursday and in snacks we get 20 minutes of free time.

Question 9: What did you think when the teacher said, "Clear your desks."?

AA-2-2: I felt good because then there wouldn't be anymore work. Because if there was any more work s(he)'d (the teacher) probably just come in and start explaining on the board.

AA-2-3: I thought s(he) was a good teacher for saying that.

Comparison and Discussion

Question 1: Student AA-2-2 interpreted the remark in terms of time. To him (her) it meant that both the teacher and the pupils would have to work quickly to get finished the lesson presentation. Student AA-2-3 interpreted it in terms of concept level of difficulty. To him (her) it meant that the concept to be presented would be easy for the class to learn.

Question 2: Student AA-2-2 revealed that s(he) had not heard it while AA-2-3 had heard but either through un-concern during the lesson or inaccurate recall did not interpret it as a teacher reprimand which it was.

Question 3: A student had been asked to come to the board and do an addition problem S(He) quickly came to the front and then stood there unable to get started. Student AA-2-2 was concerned about the loss of lesson time while student AA-2-3 gauged this pupil's behavior as unusual. The student at the board had been asked to add a linear representation of decimals and eventually added them correctly by placing them in a vertical column in an unusual manner. Student AA-2-2 commented in the SRI that s(he)'d added them in a weird manner which confused student AA-2-3. Student AA-2-3 remarked that s(he) had made a mistake (which s(he) later retracted) and surmized that s(he) had added them that way to avoid making errors.

Question 4: Both AA-2-2 and AA-2-3 interpreted this instructional move to mean that the teacher was attempting to assess their understanding of the concept.

Question 5: The teacher had just pointed out the need for including zeros as place holders when subtracting decimals and contrasted it with addition questions which didn't require this inclusion as long as the numbers in the decimals were aligned according to place value. Student AA-2-2 commented that it was just borrowing and nothing new to him (her). Student AA-2-3 observed that s(he) was putting in his (her) zeros but that they weren't necessary although this procedure worried him (her) a bit. While neither student commented on the difference in technique both indicated that they were confident in their ability to handle the borrowing required in subtraction of decimals.

Question 6: When student J_____ responded verbally to the question, "What is 7 plus 5?" with the answer 11, student AA-2-2 and student J_____ exchanged derogatory looks and comments while student AA-2-3 found it humorous.

Question 7: When the teacher said s(he) would not hand out the work sheets, student AA-2-2 felt "kind of mad" because s(he) felt s(he) could do a couple in the short time left, while student AA-2-3 was relieved because s(he) thought the work sheets "would be hard again".

Question 8: Student AA-2-3 welcomed the break which accompanied the snacks while student AA-2-2 resented the change in pattern for student turns to get and serve the snacks.

Question 9: Student AA-2-3 judged the teacher's direction favourably in terms of his (her) personal qualities while student AA-2-2 "felt good" since it meant to him (her) that s(he) (the teacher) would not be explaining anything more on the board.

Out of the 8 questions, these two students revealed three similar or identical interpretations of reactions to classroom events and 5 quite different. On the basis of these as well as comparable contextual recall data, student AA-2-2 exhibited complete confidence in his (her) mathematical ability while student AA-2-3 exhibited feelings of anxiety and avoidance reaction relative to the mathematical content of the lesson.

Student BB-2-1 and Student BB-2-2

Question 1: Why would the teacher want you to remember that example?

BB-2-1: I don't know... maybe because it's the most commonly used or something. I have no idea.

BB-2-2: Well, maybe to see if we would remember next year with the other teachers or something.

Question 2: Why do you suppose the teacher wanted you to compare the size of the fractions?

BB-2-1: Well, s(he) said that we were going to go into equivalent fractions later to tell them apart... s(he) (the teacher) was trying to see who knew what's going. And nobody put up their hand for the wrong answer. So I said, "It's good to see that all you guys are smart."

BB-2-2: Well because s(he) had said before that the larger the denominator, the smaller the piece.

Question 3: Had you noticed that one pie was larger than the other?

BB-2-1: Oh yeah, I noticed it on the board. After s(he) (a peer) said it, I noticed it again.

I: Did it make any difference to your answer?

S: Not really.

BB-2-2: Yeah. Well, I didn't really want to ask because I didn't want to - well, like be embarrassed or something .... It was kind of confusing at the beginning there but then I notices that the left-over part was smaller than the left-over part on the other one. So I knew the answer.

Question 4: Why do you suppose the teacher asks, "Are there any questions about fractions?"?

BB-2-1: Well to see if we understand it or not 'cause a lot of times some of the 'dozers' in the class don't understand it and they'll come and ask him (her) and s(he) doesn't like that.

BB-2-2: Well see, probably when we have tests most people they go up and they ask questions about if you know what this means and then s(he) (the teacher) can say. "Well I asked if you had any questions for me.".

Question 5: What was the teacher trying to do there?

BB-2-1: S(He) was showing equivalent fractions.

I: Why do you suppose s(he) used diagrams to do that?

S: Ah, you know, showing them to us in pies. Well, s(he) could have said it but a lot of the sieves in the class wouldn't have understood it. S(He) tries to use the simplest terms.

BB-2-2: Well s(he) was trying to explain what equivalent fractions were.

I: Did you understand it?

S: Yeah. I also think s(he) (the teacher) was still trying to figure out what you would use fractions for because later on s(he) said um, about the cookbook having fractions.

Question 6: Did you notice a '3/4' still written on one pie?

BB-2-1: No, I didn't.

I: Were you watching the board at that stage?

S: .... I was doing my notes and writing ... so I was hearing but I wasn't watching it.

BB-2-2: No, I didn't notice that.

Question 7: What did you think abour A_____'s question?

BB-2-1: S(He) was just rattling something off and s(he) (the teacher) couldn't understand it. And I couldn't understand it. So after I found out I couldn't understand it, I didn't listen anymore.

BB-2-2: Well, ah, I don't know.

I: Had you been listening to his (her) question?

S: No, I wasn't listening.

Question 8: Both students commented upon the same incident.

BB-2-1: B_____ asked about percentage there. I wasn't really interested in percentage. I knew we'd probably take it later. And then s(he) (the teacher) started doing something on the board. I was paying attention to him (her) and then I answered the questions in my brain. I didn't say them out loud ' cause during math - a lot to myself.

BB-2-2: Okay, s(he) B_____ did that. B_____ said something about if s(he) had 20% off from $50.00, how would you do that. And I was wondering why s(he) got onto the subject. I didn't understand what s(he) was thinking about.

Question 9: Why do you suppose s(he) (the teacher) asked D_____ to explain how s(he) (D_____) got the answer?

BB-2-1: Maybe somebody told that answer to the person or the person heard the answer from somebody. S(He) (the teacher) wants mainly, I think s(he) wants to see what D_____'s answer would be.

Question 10: In that problem, did you have any difficulty in distinguishing the girls from the boys in the picture?

BB-2-1: Not really.

BB-2-2: Yeah. There were two in there I thought they were girls because their hair was short but they had a kind of girl face.

Comparison and Discussion

Question 1: When questioned as to why the teacher had asked the class to remember the example '1/2', student BB-2-1 had no idea about the teacher's purpose in saying it yet s(he) reiterated the teacher's rationale. Student BB-2-2 surmized that it was for the purpose of recall next year. Student BB-2-1 may have considered it unimportant whereas student BB-2-2 related it to a concern over his (her) ability to recall last year's work in fractions.

Question 2: While both students perceived the comparative sizes of fractions as being relevant to an understanding of fraction concepts, student BB-2-1 related the exercise to equivalent fractions while student BB-2-2 related it to varying denominators.

Question 3: Both students had noticed the difference in the sizes of the pies being used for illustrative purposes but neither drew it to the attention of the teacher since they were independently able to eventually deduce the correct answers to the questions based on the diagrams.

Question 4: Both students interpreted this instructional move as a teacher ploy to prevent subsequent questions from students, student BB-2-1 on a daily basis and student BB-2-2 during tests.

Question 5: Both students were aware that the topic had shifted from a discussion of fractions in general to that of equivalent fractions.

Question 6: Neither student noticed a fraction (on the diagram) which was irrelevant to the new problem under discussion. It had been used in the previous problem and had remained on the diagram due to incomplete erasure.

Question 7: Neither student listened to a peer initiated question even though student BB-2-2 sat directly opposite this peer.

Question 8: Both students heard a peer ask a question about percentage. While student BB-2-1 revealed that s(he) was not interested in the topic and student BB-2-2 wondered what prompted the question, both listened to and understood the teacher's explanation.

Question 9: Both students interpreted this instructional move as the teacher's attempt to assess pupil understanding of the concept.

Question 10: Only student BB-2-2 revealed some difficulty in distinguishing between girls and boys in the picture.

The ten questions posed centered on the following facets:

(a) Pupil interpretation of instructional moves. (4) Questions 1,2,4, and 9.

(b) Format in math instruction. (3) Questions 3,6 and 10.

(c) Teacher-pupil dialogue following a pupil initiated question. (2) Question 7 and 8.

(d) Ability to monitor the mathematical content focus of a lesson presentation. (1) Question 5.

Questions 1 and 2 were related to the mathematical content of the lesson while 4 and 9 were related to teacher questioning strategies. The similar interpretations of questions 4 and 9 by both students were valid; however their interpretations of instructional moves related to math content were different. Their interpretations in question 2 were both valid but revealed differences in cognitive linkage. Student BB-2-1's linkage was more global while student BB-2-2's was analytical in that BB-2-2 linked the instructional move to a specific concept while BB-2-1 linked it to a larger construct.

Both students exhibited the ability to recognize a shift in lesson content focus as the teacher moved from a general discussion of fractions to an analysis of equivalent fractions. Their responses to four of the ten questions were different and similar or identical in six of them.

Their responses to questions 3 and 6 on the format used in math instruction revealed that teacher carelessness in format did not detract from their understanding of the concepts being taught; however, both students were above average in math achievement and both exhibited confidence in their mathematical abilities. Question 10 was related to a picture in the math text upon which a number of questions were based. One student (during the lesson) questioned the number of girls and boys in the picture, a necessary prerequisite for solving the problems correctly. Because the teacher revealed (in an SRI) that s(he) had a suspicion that student T_____ might be intentionally provoking a racially discriminatory incident by these inquiries, s(he) (the teacher) quickly glossed over this factor perhaps at the expense of a certain amount of student confusion.

Two questions were related to pupil initiated questions. The question asked by student A_____ was poorly stated and more or less ignored by both student BB-2-1 and BB-2-2 while the question asked by student T_____ was succinct and well articulated. Both students revealed that they had heard the question and had both monitored the teacher's explanation of it.

Unfortunately, teacher-pupil dialogue following a pupil initiated question is often poorly monitored, if monitored at all, by peers. Factors revealed in the study which contributed to this phenomenon included the following;

(a) Poorly stated questions.

(b) Inaudibility of pupil questions by peers.

(c) Peer inability to understand the questions.

(d) Teacher reactions to pupil initiated questions which subtly de-emphasize their relevance or contribution to the lesson presentation. For example

- failure to provide cognitive linkages to the concepts being taught.
- hurried treatment of pupil questions.
- reluctance to focus class attention on the pupil initiated question.
- teacher expectation that the question and answer would be beyond the comprehension of most students in the class.

Students CC-2-2, CC-2-3 and CC-2-4

Question 1: What do you think the teacher was trying to do?

CC-2-2: (No answer)

CC-2-3: S(He) wanted us ... to tell why s(he) doesn't do it (that is, teach this method first).

CC-2-4: Trying to give us sort of clues to try and think.

Question 2: What were you thinking when the teacher asked that question of all the boys?

CC-2-2: I was thinking of the answer.

CC-2-3: Well, I was thinking, oh, oh, I wonder what it is and then when everybody started saying the first little word, I said, "Oh yeah". So I said it with them.

CC-2-4: I was thinking about the answer.

Question 3: Why do you think the teacher asks the boys to answer sometimes and other times the girls to answer?

CC-2-2: Because s(he) couldn't decide who to pick so that's sometimes why s(he) does it.

CC-2-3: Well. I guess s(he) wants everyone to have a turn. Like s(he) wants to hear if the girls say it faster or louder or like that and if the boys say it slower or ....

CC-2-4: Well s(he wants, I think, to see who is smarter and who can answer the question.

Question 4: What was the teacher doing there?

CC-2-2: Well, showing us the old way - that's sort of to help us out.

CC-2-3: S(He) was doing the old method.

I: Did you realize that at the time?

S: Well, at the starting, I thought s(he) was going to do the new method over again but s(he) didn't for some reason. And I thought, "What kind of method is that?" And then I looked it over carefully and I said, "Oh, that's the old method.".

CC-2-4: Like s(he) wanted us to answer the questions. Like we had to sort of tell him (her) what to do.

I: What method was s(he) using there?

S: I think s(he) was using the new one.

I: The new one? Lets go back and look.

S: The old one.

I: Did you realize that at the time?

S: Yeah, but I didn't realize it just now.

Question 5: Why do you suppose the teacher went through the old method?

CC-2-3: I think s(he) was trying to show us that it's different from the new method.

CC-2-4: So we could sort of compare the two.

Question 6: What were you thinking then?

CC-2-2: That D_____'s answer was right.

CC-2-3: I was thinking that it wouldn't be there (CC-2-2's answer).... I voted for the one that D_____ said.

CC-2-4: I was thinking that D_____ was right because all the answers were there for you to add up.

Question 7: Why do you think the teacher gets students to vote on things like that?

CC-2-2: Well 'cause if someone's wrong then s(he) says, "No" and it's easier to vote.

CC-2-3: Well, I don't really know.

CC-2-4: 'Cause s(he) wants to see if we are good at predicting right answers.

Question 8: Why do you suppose the teacher gets students to make up questions?

CC-2-2: Well, because it sort of helps us out?

CC-2-3: So we can try them out to see if they'll work. And if they work s(he)'ll (the teacher) get around to using it some other time.

CC-2-4: Maybe s(he) just, ah, wants to see what different kinds of questions we can come up with.

Question 9: What were you thinking there?

CC-2-2: S(He) (a peer) made a mistake.

CC-2-3: Well s(he) (a peer) said the wrong number and well, it was a way off.

CC-2-4: I was laughing to myself because that was a basic fact and s(he) (a peer) got it wrong.

Question 10: What was the teacher doing there?

CC-2-2: S(He) was checking, I think.

CC-2-3: Like s(he) was checking it and s(he) finished that first part but s(he) had to add another one and ....I don't think s(he) (the teacher) forgot. I think s(he) just did that 'cause s(he) wanted us to say why s(he) had another 8 left.

CC-2-4: Like s(he) wanted to see if we were watching so s(he) did the wrong answer and s(he) wanted us to catch him (her) .... s(he) forgot to add the remainder, I think.

Question 11: Why do you suppose the teacher asked the students for their ideas about the remainder?

CC-2-2: Well, 'cause there's lots of answers.

I: Was there a right answer?

S: Well probably a tip would probably be the right answer.

I: Do you think people tip at the coliseum?

S: Well, I don't think so but maybe.

CC-2-2: I don't really know.

I: Was there a right answer?

S: Oh yeah. It was, someone must have left a tip. That's what teacher said.

CC-2-4: "Cause maybe s(he) (the teacher) didn't even know.

I: Was there a right answer?

S: No, because it's just a made up question. No one knows.

Question 12: Why did the teacher change that question? (From how many 6's in 7000 to how many 6's in 700)

CC-2-2: "Cause s(he) hasn't taught us that yet.

CC-2-3: That was too high of a number for us and s(he) didn't teach us it yet. So we couldn't do it.

CC-2-4: I didn't understand. I was thinking why we couldn't do that because we have done how many 6's or 8's in 8000 and s(he) didn't mind. So I don't know.

Question 13: Why do you think the teacher gave the students a choice of method to use in their problems?

CC-2-2: "Cause some of us didn't want to do the new way.

CC-2-3: Well, s(he) wants us to try both of them at least once because s(he) wants us to get a hang of it because sometimes we might have to use the new method.

CC-2-4: Because if it was too much trouble for them, s(he) didn't want them to get their brain all clogged up.

Comparison and Discussion

Question 1: Student CC-2-4's response was the most perceptive.

Question 2: Both girls were thinking of the answer although only the boys were asked to respond. Student

CC-2-3 was slower than many of the other boys (girls) in getting the answer.

Question 3: Student CC-2-3's response was the most perceptive.

Question 4: All three students in recognizing the old method were aware of the shift in content focus.

Question 5: Both student CC-2-2 and CC-2-4 gave valid responses.

Question 6: All three students agreed with the correct response although three different suggestions for the position of the quotient had been offered by the students.

Question 7: Student CC-2-4's response was the most perceptive.

Question 8: While the three responses to the interviewer question differed, student CC-2-4's response was the most preceptive. Student CC-2-2 phrased his (her) response as a question. His (her) response to this question and to others indicated that this student had perhaps seldom speculated on teacher intent relative to instructional moves.

Question 9: All three students were monitoring the lesson interaction and were aware of the incorrect answer given by a peer.

Question 10: All three students were aware of the lesson focus but only CC-2-3 and CC-2-4 revealed that they thought the teacher intentionally neglected to add the remainder (confirmed later by the teacher).

Question 11: Only student CC-2-4 denied the possibility of a single correct answer to the lesson question while the other two (CC-2-3 in particular) were guided by their impression of what they perceived the teacher to deem an appropriate answer.

Question 12: Students CC-2-2 and CC-2-3 did not question the teacher's remark while CC-2-4 was puzzled by it since s(he) felt capable of solving the problem.

Question 13 While all three responses were different they were valid interpretations of the teacher's intent.

The 14 questions asked centered on the following facets:

(a) Pupil interpretation of instructional moves. (8) Questions 1, 3, 5, 7, 8, 11a, 12, 13.

(b) Ability to monitor the mathematical content focus of a lesson presentation. (2)Questions 4 to 10.

(c) General mathemagenic behavior. (4) Questions 2, 6, 9, 11b.

Their responses differed in 8/14 questions and were the same or similar in 6/14. Their interpretations of instructional moves differed in 6 out of 8 questions. All three were aware of the lesson content focus at the two lesson points checked. They exhibited the same mathemagenic behavior in three out of four questions. In six instances, student CC-2-4 exhibited greater depth of insight relative to either comprehension of lesson content or to interpretation of teacher intent than either of the other two students. The teacher's intents as revealed in an SRI were as follows:

Question 1: To provide 'advance organizers' and to elicit speculation.

Question 3: To maximize pupil participation in the lesson.

Question 5: To provide a visual comparison of the two different methods of division.

Question 7: To foster total pupil participation and to monitor student comprehension.

Question 8: To increase pupil understanding of the math concept by providing pupil practice in formulating these concepts within different problem contexts.

Question 11a: To encourage divergent thinking.

Question 12: (This was difficult to ascertain. It may have been an error on the teacher's part or an attempt to limit the quotient to 2 or 3 digits.)

Question 13: The teacher did not expect mastery of the new concept (in a single lesson) by all students and to foster their success with the problems, allowed them to use the old method if they preferred.

Student DD-2-1 and Student DD-2-2

Question: Did you hear R_____'s answer to that question?

DD-2-1: No.

DD-2-2: No.

Question: What is the teacher doing there?

DD-2-1: Oh, s(he) wanted someone to do it and I guess s(he) didn't want someone to do it on their paper so s(he) called him (her) up to the front.

DD-2-2: Well s(he) was asking somebody if they could write down how they did it in their scribblers.

Question 3: Why do you think the teacher asks students to come to the front and do the problem on the overhead?

DD-2-1: Maybe s(he) thought you couldn't explain it. Maybe s(he) thought that you'd get a better idea of it. If you're talking about it, it's easier to do it on the chalk board than it is to say something.

DD-2-2: I don't know.

Question 4: (A student had just worked a problem on the overhead. The teacher asked him (her) to explain how s(he) (the student) obtained the answer and then the teacher completed the notation and put the answer in lowest terms.

DD-2-1: The teacher asked J_____ how s(he) did it that way an I sort of had the same question in my mind. But I was thinking -- like s(he) (the student) did it a shorter way than me .... instead of listing a whole bunch of equivalent fractions s(he) just listed two equivalent fractions and did the rest in his (her) head.

DD-2-2: The teacher was just finishing it off and putting it into lowest terms.

Question 5: What did you think about H_____'s method of doing that problem?

DD-2-1: It probably wasn't as good .... I think either s(he) did it a really short way or a really long way. I can't remember. But I think s(he) should have done it the way we were taught to do it.

DD-2-2: Well, I couldn't really understand it ... I wrote down all the multiples. Neither J_____ nor H_____ did that.

Question 6: What were you thinking then?

DD-2-1: I was wondering why s(he) had it at 20 ...., it could be at 10.... I knew it would be right 'cause I remembered from him (her) (the teacher) explaining that before.

DD-2-2: I was wondering why s(he) used the 20th's 'cause I didn't quite understand it.

Question 7: Why do you think the teacher chose a common denominator of 1450?

DD-2-1: To show you can use any of them almost .... But it's better to get lower ones, like the lowest common multiple.

DD-2-2: I can't remember.

I: It was the same question. S_____ did it with 20th's, D_____ did it with 10th's and then the teacher chose to do it with a common denominator of 1450. Why do you think s(he) did that?

S: Well, it's a bigger number .. so it can be the same.

Question 8: What was the teacher doing there?

CC-2-1: S(He) was rounding off 29 to the nearest multiple of 10.... it's easier but sometimes inaccurate.

DD-2-2: Well 29 is quite hard to divide so you round it off to 30 'cause it would make it easier.

Question 9: What was the teacher trying to do when s(he) asked for someone in B_____'s row to answer the question?

DD-2-1: Like I guess s(he) found everyone in B_____'s row sort of lazy and asleep. And I think s(he) wanted to get everybody awake again.

DD-2-2: Well some of the people in our row weren't paying attention -- so to make them pay attention.

Comparison and Discussion

Question 1: Neither student heard R_____'s answer. Nor were they aware of the two errors made on the overhead. In listing the multiples of 1/2 which the teacher wrote on the overhead, R_____ had omitted one (2/4) and given an incorrect one (8/10). While a number of students interjected at this point, only the missing multiple was added; the incorrect one remained on the overhead.

Question 2: Both students were monitoring the lesson presentation at this point. When the teacher asked someone to come to the overhead to do the question, student DD-2-2 revealed that s(he) did not like "doing things in front of the class" and therefore did not raise his (her) hand. On the other hand, student DD-2-1 raised his (her) hand, let it rest on his (her) head and although s(he) thought that the teacher looked at him (her), felt that s(he) should have kept his (her) hand up. Student DD-2-1 did have an opportunity later to do a question on the overhead and revealed a number of concerns prior to and during his (her) performance. S(He) disclosed that s(he) first looked for the answer in the text, was undecided whether or not to take his (her) book up with him (her), whether or not to write down all the multiples, whether s(he) would be embarrassed or not, found one answer and did the other in his (her) head as s(he) was walking up, and whether the other students would be able to read his (her) work on the overhead.

Question 3: Student DD-2-1 gave a valid interpretation but student DD-2-2 had no idea. Generally student DD-2-2 exhibited a lack of interest in interpreting the teacher's instructional moves.

Question 4: Both students were monitoring the lesson but student DD-2-1 focused on the student's method and DD-2-2 on the teacher's additions to the solution.

Question 5: Both students noted the difference between H_____'s method and their own. Student DD-2-2 didn't understand H_____'s method while DD-2-1 voiced the opinion that H_____ should have done it the way they were taught to do it.

Question 6: Both students wondered why a peer had chosen 20th's as the common denominator. Student DD-2-1 knew the answer would be right while DD-2-2 didn't understand it. In considering the use of 20th's or 10th's student DD-2-1 was interested in comparing the amount of work required to solve the question using different denominators and drew several conclusions. On the other hand student DD-2-2 disclosed that s(he) also had used 20th's and stated that s(he) just multiplies the bottom numbers together to get a common denominator and so wouldn't use 10th's. Yet s(he) was rather vague about whether s(he) always used this method.

Question 7: Both students grasped the significance of the teacher move; however, only DD-2-1 mentioned using the LCM while DD-2-2 stated that s(he)'d just use a smaller common denominator.

Question 8: Both students recognized the teacher's purpose in using 30 instead of 29 as a divisor for estimating the quotient.

Question 9: Both students interpreted this move as an attempt on the part of the teacher to get the students to pay attention as both were aware of the overt actions of several students in the row. At this point student DD-2-1 surmised that the teacher would then continue to ask questions by rows (which s(he) didn't do) and DD-2-2 who had just given an incorrect answer was wondering whether the rest of his (her) answers would be correct consequently his (her) attention was divided.

Of the 9 questions asked, six of the student responses were the same or similar and three different. These questions centered on the following facets:

(a) General Mathemagenic Behavior. (5) Questions 1, 2, 4, 5, 6.

(b) Interpretations of instructional moves. (3) Questions 3, 7, 9.

(c) Ability to identify lesson focus. (1) Question 8.

It was difficult to compare the responses of these two students as their recall was not as extensive as with previous students interviewed. Student DD-2-1 was distracted by many factors and monitored the camera throughout the lesson while student DD-2-2 worked problems at his (her) desk and monitored the lesson presentation intermittently.

APPENDIX J

PARENTAL CONSENT LETTER FOR PUPIL PARTICIPATION

FACULTY OF EDUCATION
OFFICE OF THE DEAN
CENTRE FOR RESEARCH IN TEACHING

THE UNIVERSITY OF ALBERTA
EDMONTON, CANADA
T6G 2G5

To The Parent:

As part of a research study being conducted by *The Centre for Research in Teaching* at *The University of Alberta*, we would like to interview your daughter (son) at the conclusion of a videotaped lesson at her (his) school. The student will be asked, while viewing the videotape, to recall her (his) thoughts, feelings and impressions at specific points in the lesson. All tapes and transcripts are confidential.

If this meets with your approval, would you please sign below and have this form returned to the teacher as soon as possible.

Yours sincerely,

A. MacKay, Ph.D.
Director, Centre for
Research in Teaching

AMacK/lb

(Note: The project in question has been approved by the principal of the school.)

Signature ....

APPENDIX K

TEACHING STYLE AND IMPLICIT THEORIES

TEACHING STYLE

Teacher A

I hate to do half a page and leave it.

I prefer that _____ asks me for help.

I don't expect pupils to learn math and eat snacks.

I shouldn't be annoyed when students are reluctant to stop working on worksheets that they enjoy doing.

We always date our work.

I use the dates to keep track of which pupils have missed certain sections of the work.

Normally I start with grade five and go down the rows for turns in getting the snacks.

Teacher B

I encourage students to use one method of the three shown because it's easiest and fastest.

It's pointless to wait for a student to answer if s(he) doesn't understand the concept.

When I sit down at my desk I get a ring of students around my desk if they haven't understood the concept taught.

Teacher C

I talk too much during instruction.

I like to do adult things with the students.

I prefer to be forthright about their relations with others.

I like kids to get things right rather than wrong.

I use my student assignments in deciding who to re-teach.

I often make deliberate errors that students tend to make.

When I don't want students to help each other I tell them.

I often get students to make up example problems.

I insist on certain procedures that I prefer the students to use.

I use oral group responses a lot in my lessons.

I'm rather tough in marking.

We work on a little rule that you can't minus more than you start with.

I use this rule to prevent student errors in subtraction.

I keep working on common student errors all year long.

I like kids to be successful.

I don't like to introduce too many things at once.

I'm quite capable of making multiplication errors unintentionally.

Teacher D

I generally don't ask a child a question if I know s(he) doesn't know the answer or has a poor self-concept.

I'm the type of person who doesn't mind repetitive sorts of tasks.

Usually I expect more than one or two volunteers to answer questions.

The normal procedure is to check their assignment first, present the lesson and then let the students do practice problems.

It's a question I always ask.

IMPLICIT THEORIES

Teacher A

Concrete examples help pupils learn the concept.

You can maintain motivation by capitalizing on pupil interest in specific areas.

Teacher neglect of pupil desires causes frustration.

The part of school that some kids hate is when they build up anticipation and enthusiasm only to be let down all the time.

An intelligent person uses the easier way to solve a problem.

Simplified format improves mental computation.

Pupils have different cognitive styles.

Math is an abstract subject and pupils can get fouled up in so many little things.

Math is a subject pupils worry about more because it's tricky and it's more obvious when they don't know it.

Pupils think math is hard because they're told it is by other pupils and parents.

If you tell them often enough that math is easy they'll get brainwashed or get rid of some of the negative thinking.

I don't think math's hard but that's because I've never had any trouble with it.

After a couple of years of teaching you catch on to the type of things that pupils have trouble with in math.

Something teachers don't think about is whether they ask for answers too soon. They don't give students enough time to think about the answer.

Before any holiday pupils are pretty restless.

Pupils can trick teachers about their understanding of a concept. They do it for various reasons: They want to be left alone, they're bored with it, they're being challenged too much or they're embarrassed.

It's better to broaden pupil knowledge of concepts than to cover part of the next year's curriculum.

Many pupils are mentally lazy.

Television viewing adversely affects thinking power.

Pupils don't think as well as they used to.

Pupils don't know how to entertain themselves internally.

Above average students can be trained to be independent thinkers and workers.

Pupils are slow on Mondays.

A lot of kids feel that math is difficult.

Pupil difficulty in math is often unrelated to how bright they are.

Incorrect marking of questions can confuse students.

Teacher B

Examples that students understand rather than elaborate terminology should be used to teach concepts.

Fifty per cent of learning is paying attention in class.

Students realize that you make mistakes and they make mistakes. You get a sense of awareness after awhile if you know the pupils, which ones you don't push too far and which ones you do. It's all part of teaching.

Students need to learn to take notes in class.

Math competency is a reflection of the way students think and of their language comprehension.

Some students are afraid to ask questions in class.

Some students try to make themselves look funny in class.

I believe that the fraction 1/2 is referred to more than any other fraction.

A simple fraction is something that they can understand.

Because math works with numbers it's sort of straight forward and the kids enjoy that.

Math you can do more off the board than anything else.

Pupils have a tendency to get embarrassed if they show their ignorance.

Peer influence starts at the grade six level.

Pupils are still confused about the change to the metric system.

Pupils in grade six resist the metric system because they were taught the British system first.

Pupils should be informed about curriculum changes.

Some pupils try to get attention through futile arguments.

Some pupils are easily embarrassed.

It's alright to persevere if you think the pupil will eventually get the answer.

The problem of teaching is to more or less know when to ask another pupil for the answer.

This knowledge (above) comes with experience.

If you pressure pupils to answer they become afraid to answer and this inhibits discussions.

Being free to answer or make a comment is part of learning and understanding.

Pupils don't have to take notes to learn the concept being taught.

Teacher C

Children like to guess.

Organization of boardwork is important.

Division with two-digit divisors is hard to teach.

If there are too many little processes, pupils forget the whole process.

If pupils construct their own problems they understand the concept far better than I can teach it.

Money problems are easier for kids to understand than other kinds.

If the kids teach one another my job is easier.

If kids are actively involved they maintain interest in the lesson.

If the first answer to a question is wrong, it affects pupils' attitudes toward math.

Pupils tend to learn what they hear first.

Wrong answers first make your teaching harder.

Teachers shouldn't start talking until all the pupils are ready to listen.

Listening is one of the hardest skills to teach.

Teachers talk too much in class.

Going through the complete process in division serves two purposes: It eliminates errors with zeros and it fosters accurate estimation.

Checking seatwork in progress and individual assignments reveals those students who must be re-taught the concept.

Pupil ability to re-state a problem is important in problem solving.

I don't believe in ability grouping in math since it cuts instruction time.

If you make math understandable and fun, the smarter students don't suffer.

A teacher can outstep the bright students.

The partial quotient method of division encourages inaccurate estimates.

The number of calculations in the partial quotient method increases the probability of error.

Getting students to think of different ways to solve a problem develops their functional intelligence.

Students taught a variety of methods of solution will use a variety of methods in solving problems in other areas.

I don't believe in teaching the partial quotient method as the primary method for division.

Kids don't always know what the problem is.

Identifying a problem involves a higher step in thinking.

It's important for the kids to understand the relationship of money.

It's important that kids understand mathematical terminology.

If you slow down too much, they lose track of the whole process.

Kinds tend to make the same kinds of errors all through elementary school.

Kids love to work on the board.

Kids like variety and so do I.

The hardest basic facts to learn are addition and subtraction facts.

Teachers tend to give more prompts than they need to.

The most important part of math is teaching strategies for problem solving.

Children need opportunities to devise different methods of solution.

Students often anticipate what I'm going to ask and respond to that rather than to the question asked.

Children need opportunities to try new things.

It's important that children not be afraid to try new things.

Kids commonly make errors when subtracting from zero.

Kids would rather solve problems which they construct.

Kids have trouble with zero in division.

Pupils should be given practice in re-stating the problem in their own words.

Listening skills need to be taught to some pupils.

It's important to develop pupils' functional intelligence.

Teacher D

Long lesson presentations require interest breaks.

When a child is having trouble in math s(he) needs or wants attention to the problem immediately.

Some students chronically give answers in low voices while other need to be toned down.

Many students are always looking for shorter, easier ways to do math.

It's usually brighter students who ask for a shorter way to do math.

The perpetual problem of a math teacher is to bring students to some degree of understanding about the process involved before using a short cut.

The algorithm for finding common multiples is necessary for student understanding.

Addition and subtraction of fractions with like denominators to those with unlike denominators is an important transition point.

You learn from experience not to ignore it when something is not working properly.

Students think that if they've missed work it's not necessary to follow the checking.

Format is not as important to bright students.

It's necessary and important for teachers to emphasize process understanding.

Even though we stress that fractions are equivalent, children still don't believe that they are equal and equivalent.

There is no way of solving the problem of voice modulation in pupil verbal responses.

Building sets of equivalent fractions is a necessary step in determining the LCM.

APPENDIX L

CASE STUDY OF LESSON C-2

CASE STUDY OF LESSON C-2

This lesson on the partial quotient method of division consisted of an introduction, an illustration on the blackboard, several pupil proffered examples which were solved individually by the pupils, corrections of these problems on the board, and a lesson closure. The introduction included

1. the general topic of the lesson (a new method of division)
2. an advance organizer (a question to be answered at the end of the lesson presentation, and
3. speculation about process.

During the introduction, student initiated questions were answered, guidelines were outlined for future pupil use of the new method, and a teacher expectation for pupil success with the new method was expressed.

The teacher chosen example which had no remainder was presented numerically and within a situational context. Students were asked to verbalize the numerical quantities in the problem and to re-state the question in terms of context. The numerical problem was written on the board and students were first asked to estimate the quotient.

The same problem was solved using the new method and then by using the old method with which the pupils were already familiar. Each step in the algorithm was provided by pupil responses to teacher questions. During this illustration, questions were addressed to individual pupils, the girls, the boys and to the whole class. The pace of the lesson was brisk for convergent questions but was decreased for divergent questions. Pupils were asked to express their collective or individual agreement or disagreement with correct and incorrect peer responses to questions. After a class decision to sum the partial quotients, they were asked to speculate on the position of the quotient. After three suggestions were elicited, they were asked to vote on the one they surmized would be the conventional position. The rationale for this placement was then discussed.

Students were then asked to construct different problems, place them in a situational context and then solve them individually. The only control exercised by the teacher was that the divisor be a single digit and the quotient contain no more than three digits. Although students were given a choice of method to use in solving the problems, they were encouraged and challenged to use the new method or both methods to provide a check for their answers. The teacher monitored the number of pupils who used the new method and during the seatwork, checked each student's work to identify those who might need individual help or re-teaching of the concept.

A cluster of instructional moves was repeated for each problem. Each cluster constituted a heuristic strategy which elicited pupil information processing at varying levels. While there were variations in the sequencing of these moves, they invariably ended with a divergent question.

A pervasive objective throughout the lesson was a teacher intent to elicit maximal mathematical information processing by all the pupils and to guide their thought processes. Pupils were expected to relate their computations to realistic situations and to interpret their solutions in terms of the problem context.

Consistency in process which was linked to previously taught lesson concepts was maintained to allow students to focus on those aspects of the problem that were new and different to them. Estimation, speculation, and divergent thinking were required of the students intermittently throughout the lesson. Students were asked to construct problems and verbalize both the question and the answer. These verbalizations placed the numerical facets of the problem in relevant contexts.

Distractor control was exercised by the teacher in both lesson content and lesson organization. Introduction of the name of the new method was delayed deliberately until the pupils had had a chance to assimilate the new algorithm.

Reinforcement and consolidation of the new method were provided through the correction on the board of several problems after the students had solved them at their desks.

The teacher disclosed a deliberate use of these instructional tactics to achieve specific lesson objectives. Several of these included the following:

To provide advance organizers.
To elicit speculation.
To increase their estimation skills.
To maximize pupil participation in the lesson.
To provide a visual comparison of the two methods of division.
To monitor student comprehension.
To increase pupil understanding of the concepts.
To encourage divergent thinking.
To provide pupil practice in formulating concepts within different problem contexts.
To develop their functional intelligence.

Several of the teacher's goal statements that were reported in the SR interview were as follows:

I wanted the kids to feel secure after the lesson.
I was hoping that eventually they would see that the understanding is more important than the method used.
I was hoping that the kids would see that it was per-

> haps difficult in terms of keeping track of the zeros and that that particular method was exactly the same as the one that we're using except that the place value wasn't taken care of.
>
> I didn't want to give them any clues. I wanted them to figure that out themselves. (I did that deliberately) so the kids would understand that their parents are actually doing it a proper way. It's just a different way.

The teacher's instructional moves were linked to these objectives and goals. This deliberate use of heuristic moves constituted a basis for establishing criteria upon which to assess the impact of instruction upon pupil information processing levels. It seemed that the teacher merely guided the procedures while the pupils had to do all the thinking. Yet, it represented a planned instructional strategy which pervaded the lesson from beginning to end. It also forced students to monitor intermediary operations and placements of numbers in case of intentional teacher errors chosen on the basis of potentially common pupil errors.

The heuristic moves were evident and frequent enough to constitute heuristic stragegies. Four heuristic moves A and seventeen heuristic moves B which occurred repeatedly throughout the lesson were identified. A model for these strategies might take the following form.

	Teacher Information Processing to provide for	Pupil Information Processing required for
Introduction:	Motivation Advance Organizers	Speculation about process. Speculation about advance organizer.
Presentation of Lesson Concept:	New algorithm New format Analogies and comparisoms Problem context	Decoding through recall of basic facts, known algorithm Encoding of new processes new format new algorithm rationale for format
Pupil Seatwork and Correction of Problem	Supervision of seatwork, Identification of pupils for re-teaching. Control over distractors. Diagnostic correction of problems. Monitoring of pupil use of new method.	Decoding of problem context new algorithm Encoding of functional application interpretation of remainder
Closure:	Advance Organizer question	Encoding of teacher motive and method analogy

The lesson opening and closure elicited divergent pupil thought processes while the lesson body employed an appropriately sequenced mix of convergent and divergent questions.